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FOREWORD

KENYA.

First published in April, 1908, the original *Agricultural Journal of British East Africa* was discontinued in July, 1914, and since the War the need for a new Journal has been urged from time to time by progressive farmers and by farmers' associations. That the Journal has at last come into being is due in great measure to proposals made at various agricultural conferences by my predecessor, Mr. Alex. Holm, C.M.G., C.B.E.

The Journal should make a wide appeal not only to those whose livelihood is farming but also to those whose well-being depends on agriculture; and in these territories, where prosperity and the advancement and development of agriculture march hand in hand, it is difficult to think of any section of the community whose interests are not largely affected by agricultural progress.

By keeping farmers in touch with the progress of successful agriculture throughout East Africa it is hoped that the Journal will assist them in their efforts to improve farming methods. The Journal should also serve a useful purpose by strengthening the ties between agricultural communities who have common interests in neighbouring territories.

I sincerely hope that this Journal will receive the support of all of us in Kenya who are interested in the advancement of agriculture in East Africa.

H. B. WATERS.

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TANGANYIKA.

This is the first issue of the *East African Agricultural Journal,* and it is trusted that it will have a long life and a prosperous career. Furthermore, it is hoped that, as a publication, it will prove of practical value to the planter, farmer, and administrator in these territories.

Obviously its scope has to be restricted in the beginning, but as time goes on, and the needs of the farming public are better understood in connection with the publication of advice and information, it is anticipated that the Journal will appeal to a wider circle of readers.

Agricultural problems in Eastern Africa are not particularly restricted by territorial boundaries, and information gleaned in any one quarter is usually of value generally. It will perhaps do a great deal in bringing the farming problems in East Africa into focus, and incidentally bring planters and farmers together as they come to realize that their interests and their problems, to a large extent, admit of uniform treatment.

To many administrative officers the publication should prove of value, particularly as the native agricultural section is developed.

E. HARRISON.

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UGANDA.

The publication of an East African Agricultural Journal has been under contemplation since 1926, when Mr. Alex. Holm raised the question at the South and East African Agricultural Conference held at Nairobi. The many practical difficulties have now been overcome, and it is hoped that the Journal will find a permanent and increasingly useful place in the agricultural life of these territories.

Taking these territories together, there is a large amount of practical research work being done on a variety of crops, and the volume of this work is growing. So far, however, there has been no simple way of passing on to the man on the land the practical results of this experimental work, and the Journal should assist very materially in the dissemination of this useful information.

J. D. TOTHILL.

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ZANZIBAR.

Agricultural problems in the Zanzibar Protectorate differ materially from those in the mainland territories, but nevertheless the scope of the *East African Agricultural Journal* should be such that the publication will be of real value to those engaged in agricultural pursuits in the " Spice Islands," particularly to agricultural and administrative officers.

Zanzibar trusts that this new venture, which is so deserving of whole-hearted support in East Africa, will prove of value to tropical agriculture generally and attain a widespread distribution even beyond the limits of the East African Territories.

A. J. FINDLAY.

EDITORIAL NOTES

TUNG OIL TREES IN EAST AFRICA.

The efforts made from 1927 onwards to establish tung oil production on a commercial scale in East Africa should by now be producing indications of the measure of success to be expected in the acclimatization of *Aleurites Fordii* and *A. montana* under a wide variety of conditions. Surveys of the situation might with advantage be undertaken and published by the Departments of Agriculture. Meanwhile, information from growers would be welcomed.

Seeing that most of the original production in China is from *A. Fordii*, that *Fordii* has been successfully established on a commercial scale in Florida, and that the seed is much more readily available, it is natural that most of the trials have been made with this species. Evidence already existed in the Forest Department's Arboretum at Nairobi that it was capable at any rate of growing and fruiting in Kenya.

Early reports gave evidence of satisfactory development of *A. Fordii* in certain districts in Kenya and in the Southern Highlands of Tanganyika; all, so far as they are known to the writer, at relatively high altitudes. In Northern Tanganyika results appear to have been uniformly disappointing.

There is a peculiar irregularity of development in this species. In unsuitable localities a very small proportion of the young trees develop after planting out; the rest survive, but make hardly perceptible growth. Even in the most suitable conditions seen, there is still irregularity, but the proportions of thrifty and unthrifty trees are reversed.

Aleurites montana, in spite of its name, is much more amenable to low altitudes in the tropics. There is a fairly general agreement to this effect in the reports received from other British colonies. It thrives well at Amani (3,000 ft.), and the earliest trees to fruit give promise of adequate bearing. Recent expressions of individual opinion received from Kenya show that some growers, even at altitudes where *Fordii* makes good development, are beginning to look upon *montana* as the better species.

This situation raises the question of the respective commercial merits of the oil from the two species, and this is dealt with authoritatively by Dr. L. A. Jordan, Director of the British Paint Research Station, in a lecture delivered before the London Section of the Society of Chemical Industry in October, 1933. Knowledge regarding pure *montana* oil is admittedly scanty, but tests of authentic samples show that it is not inferior in its technical properties to tung oil as now used. It does not, however, conform to the present chemical specifications for tung oil, and it is an unfortunate fact that the oil from *Fordii* can, by adulteration with about 5 per cent of cheaper vegetable oil, be made to respond to tests designed for pure *montana* oil. In spite of this difficulty, as there is every prospect of *montana* oil from reliable sources coming on to the market, it is urged as most desirable that special standard specifications should be issued and recognized by the trade.

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TUBA ROOT.

There is evidence from many directions of the active interest which is being taken in agricultural and commercial circles in the production and use of the species of Derris marketed under the name of "tuba root". Originally used in Malaya as a fish poison, tuba root has gained ground rapidly, especially in the U.S.A., as an efficient insecticide, practically non-toxic to man or domestic animals. It thus comes to some extent into competition with pyrethrum. The latter has the advantage of quicker action

—stunning effect—but Derris is regarded as more certainly lethal. This difference has led, in some preparations, to the combination of the two substances.

Although tuba root has been the subject of much chemical investigation, the basis of its toxic effects remains highly uncertain. At least four compounds have been recognized which may be concerned, of which rotenone has received most attention. In the U.S.A. the commercial value of the root is assessed on the basis of rotenone content; in England it is either based on the total ether extract or merely on appearance. It is understood that a new method of chemical assay, "more equitable and scientific", is shortly to be published by American investigators.

The ultimate test of value as an insecticide must be directly based on toxicity to insects, but as in the case of pyrethrum, where similar questions arise, methods of biological assay have proved to be difficult and unreliable, largely owing to the impossibility of securing perfectly uniform living material, and of maintaining uniformity in the conditions which affect the test.

The latest efforts in this direction, carried out with great care and consideration, are recorded in Bulletin No. 16 (Scientific Series) of the Malayan Department of Agriculture: *The Toxic Value of Derris spp.*, by N. C. E. Miller. Three kinds of Derris root were tested, one with a high ether extract and high rotenone content, one with high ether extract and low rotenone, and one in which both factors were low. The conclusion reached after three hundred and forty-seven tests was "That, as regards toxicity to the subjects used in the investigations, there is little to choose between them, and that the rotenone content is not necessarily a reliable index to the toxic value."

The rotenone content of Derris root is very variable. The percentage (on a moisture-free basis) in thirty-two samples from the Dutch East Indies ranged from 0.3 to 10.9, with an average of about 3. This variability has given rise to dissatisfaction on the part of American manufacturers, who buy on the rotenone content, and has led on the one hand to inquiry regarding possible substitutes, and on the other (in the producing countries) to efforts to establish high-yielding strains.

A South American alternative (cubé), the root of *Lonchocarpus nicou*, is reaching the New York market in rapidly increasing quantities from Brazil, British Guiana and Peru. Like Derris, it is sold on its rotenone content. Among many East African native fish poisons examined there are two, *Tephrosia vogelii* and *Mundulea suberosa*, which have definite possibilities and are the subject of continuing and active investigation at Amani.

Trials of Derris have been going on at Amani since 1928. Growth is all that could be desired, but the earlier chemical analyses gave low rotenone contents. Later results, however, are more encouraging. Roots harvested at 2½ years gave 5.4 per cent, and at 3½ years 9 per cent. The latter determination was made on a sample of the bulked roots, thick and thin. Our own attempts at biological assay, carried out with various insect types, show little or no correlation between toxicity and rotenone content, and the total ether extract was the same (19.5 per cent) in both the analyses just quoted. We have no reliable evidence of yield, but in Malaya this is given as 800-1,200 lb. per acre at 18-22 months. The species most usually grown is *Derris elliptica*, with more or less prostrate habit, and *D. malaccensis* var. *sarawakensis*, which is erect. The former contains more rotenone, but the total ether extract is about the same. The plants are reproduced from stem cuttings.

Exports from Malaya rose from about 90 tons in 1930 to 570 tons in 1933 and 481 tons in 1934. Further large increases are foreshadowed by the extension of planting. Java, Sumatra, and the Philippines are also likely to increase production, and the selection of strains with a high rotenone content is receiving close attention. Derris with 4 per cent rotenone was priced in the New York market in November, 1934, at 30 cents per lb. Singapore prices quoted for February, 1935, average 7¼d. per lb. sold on ether extract, 9¾d. on rotenone content, and 1/2¾d. for Singapore dried root.

CINCHONA IN EAST AFRICA.

As a result of the introduction of seed from Java in 1902, and by virtue of its suitable climate, the Amani Research Station early became and has continued to be the main African centre of experimentation with Cinchona. A complete account, so far as the records serve, of yields and analyses of the bark produced, by Dr. R. R. Worsley, is due to appear in the Bulletin of the Imperial Institute. The Amani Cinchona plantations played an important part in the East African campaign, and General von Lettow-Vorbeck states (*My Reminiscences of East Africa*) that not only was sufficient quinine for the full needs of his troops derived from this source, but they were enabled to send a quantity to Germany to make up for the shortage there.

Trials on a small scale, with results which are understood to be satisfactory, have been made in Uganda, and efforts are being made to establish the crop in Northern Rhodesia. Introductions to the Belgian Congo have so far apparently not met with much success. A small amount of commercial production goes on from the German-planted coffee estates in the East and West Usambaras in Tanganyika Territory.

Shipments from Amani in 1932-33, amounting to some 35,000 lb. of Ledger, red, and hybrid barks, for which there was keen competition in London, awakened a demand for further supplies. As a consequence, numerous inquiries and orders for seed have been received, including several from Kenya. It is therefore a matter of some direct interest to review the existing situation as regards markets and to indicate the agricultural conditions which the crop demands. Indirectly, the possibilities of East African production have an interest for everyone in the country, since all are concerned with the prospects of more extensive control of malaria which would follow on action resulting in the cheapening of quinine.

It is a familiar fact that world supplies, to the extent of some 90 per cent, are derived from the Dutch East Indies. The Indian Government plantations, which have had a long and chequered career, still produce less than half of the local consumption. Commercial production in India and Ceylon, at one time considerable, has long ceased in favour of tea-growing. The Dutch monopoly, owing to the associations of the word, is not infrequently mentioned in accents of reproach. Consideration shows that it may justly claim to have been beneficial in its action. The Dutch owe their original control of the industry, in the preliminary stage of which Britain played an important part, not only to the suitability of conditions in Java for the crop, but especially to the early application of botanical science to the improvement of yield. When low and fluctuating prices made production unprofitable and extinguished competitors, a scheme of marketing control was adopted, and it is on this basis that the industry has continued to exist and to supply the world with an essential commodity at prices which are usually regarded as representing only a fair margin over the costs of

production. As apologists have pointed out, no attempt has been made to withhold supplies of seed, and there is nothing to prevent other tropical countries from undertaking production. So far, however, from there being any shortage of supplies to meet the present demand, it has been found necessary to restrict output.

Since it cannot be denied that the beneficial use of quinine, if it were cheap enough, could be enormously extended, the situation has been aptly summed up in the remark that "Quinine is the rich man's remedy, while malaria is the poor man's heritage." The Indian Government, faced with this problem in an acute form, has made long-continued efforts to develop State-owned plantations and factories. Recent figures show that considerable economies have been thus effected, but, as mentioned above, supplies are not yet nearly adequate even for present requirements. Extension is understood to present difficulties owing to shortage of suitable land not already occupied by other crops.

The present trend in East Africa is towards the increase of estate production for the London market. So long as this remains comparatively insignificant, as it seems probable it will, growers will no doubt retain the benefit of controlled prices, and so long as Holland remains on the gold standard, the very considerable advantage of the difference in exchange. The price of quinine, under these circumstances, would not be affected.

Wider development, even remotely proportionate to the vital interest which East Africa, like India, has in cheaper quinine, would seem possible only under some form of Government organization, directed towards production for local consumption. Whether, if such a policy were embarked upon, it should follow the Indian pattern, or take the form of central factories supplied by private growers, is a matter for discussion.

First consideration would have to be given to the extent to which areas providing conditions suitable to cinchona cultivation exist and can be made available. (There might, for example, be a conflict between cinchona planting and forest conservation.) So far as one can generalize on such a matter, it may be said that the requirements of cinchona are much the same as those of tea—elevations verging on 3,000 feet or more, up to near the frost line, and a well-distributed rainfall. One writer suggests for Java a minimum of 100 inches, but 70 inches at Amani seems more than adequate, and the opinion may be hazarded that even 50 inches, if distributed throughout the year without lengthy dry periods, might suffice.

From the practical point of view, only two species of cinchona need be considered: *C. Ledgeriana* and *C. succirubra*. The universal difficulty of cinchona cultivation has been that the former species, which gives satisfactory yields of quinine, is less vigorous in its growth, is more selective in respect of conditions, and is reported to be difficult or impossible to regenerate on the same site. *C. succirubra,* which is its opposite as regards size, vigour, and selectiveness, has a quinine content so low as to make its extraction as such unremunerative, although its yield of mixed alkaloids is fairly high. If cinchona febrifuge, prepared from this species, were to be adopted in local medical practice, for which, so far as its therapeutic value is concerned, it is admitted to be effective, the yield per acre would be much larger and the possible area considerably extended. For quinine production, present practice in Java, after a period in which hybrids between the two species were used, is to graft *Ledgeriana* on *succirubra* stocks.

The question of synthetic substitutes for quinine, which has complicated this

subject, appears to have worked itself out, for the time being at any rate. Only one substance has been produced which is both safe and efficient. It may be expected to remain a complete monopoly for many years to come, and its price seems likely to exclude it from effective competition for general usage, even with quinine.

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A PRELIMINARY NOTE ON AN INTERESTING PARASITE OF *ANTESTIA LINEATICOLLIS*

Antestia is one of the most serious pests of Arabica coffee in East Africa. Strepsistera is one of the most fascinating orders of insects, yet few people, even among entomologists, have any first-hand acquaintance with these elusive but interesting parasites.

It is therefore of some importance from the practical as well as from the scientific point of view to record that I have found a species of Strepsistera parasitizing *Antestia* in large numbers in the Moshi and Arusha districts.

The Strepsistera is a small order of insects related to the Coleoptera (beetles), all of which, with one or two recently discovered exceptions, are parasitic on insects, the majority on Hymenoptera (ants, bees and wasps) and leaf-hoppers (Jassidæ and Fulgoridæ). Their structure and life-history are both equally remarkable. The adult male is at least recognizable as an insect, having the usual six legs, one pair of large fan-shaped wings —the *front* pair of wings are represented by small club-shaped organs, similar to the "halteres" which take the place of the *hind* pair of wings in the Diptera (flies, mosquitoes, etc.)—and a pair of curious flabellate antennæ. It has, however, no functional mouth-parts, and on emerging from the host lives only for a few hours, during which its sole concern is to fertilize females of its species.

The female never leaves its host; it possesses neither legs, eyes, antennæ nor mouth-parts. Shortly before it becomes mature, it extrudes its fused head and thorax between two of the abdominal segments of its host, its abdomen, which becomes greatly distended with eggs, remaining entirely inside the body of the host. The eggs hatch within the body of the female, from which the young larvæ emerge in enormous numbers. This first-stage larva is a minute, six-legged, active insect, which crawls about until it finds a new host, to which it attaches itself, and into the body of which it ultimately penetrates. There it loses all semblance of an insect, becoming to all appearances a mere sack without any appendages, which feeds on the blood of the host by filtration through its thin skin. The male has a definite pupal stage, still within the body of the host; the female, as stated above, remains laviform throughout its life.

Insects attacked by Strepsistera are commonly said to be "Stylopized"—a a word derived from one of the best-known genera, *Stylops*, which parasitizes certain bees and wasps.

These parasites do not as a rule cause much premature mortality among their hosts, their efficiency lying in the fact that they render the female host incapable of egg-production, and the male incapable of fertilization (though the latter may not invariably be the case).

The biology of the species found parasitizing *Antestia* appears to differ in a number of important particulars from what little is already known about the biology of other species of these insects. It is not, however, intended to give any particulars here, as this insect is at present being studied in as great detail as possible, both as regards its life-history and possible importance as a controlling factor of *Antestia*. T.W.K.

The Inoculation of Leguminous Crops

By J. McDonald, D.F.C., B.Sc., F.L.S.,
Senior Mycologist, Kenya Colony.

The observation that land on which leguminous crops have been grown is improved for the succeeding crops is many hundred years old, but the fact that this is due to the activities of bacteria living in the small swellings, usually called nodules, which occur commonly on the roots of leguminous plants has only gradually become known as the result of investigations carried out by various scientists during the past century.

In 1838 Boussingault published results of chemical experiments by which he proved that soil in which clover had been grown showed a definite gain in nitrogen, whereas wheat under similar conditions produced no such effect. He went so far as to express the opinion that the atmosphere was the source of the added nitrogen. Boussingault was followed by other workers, who established the fact that legumes grown in sterilized soil were unable to accumulate nitrogen. The possible role of the root nodules in this connection then appears to have aroused curiosity. The actual existence of these had been noted centuries earlier, but it was not till 1858 that their formation was observed to be due to bacteria. Later it was demonstrated that leguminous plants bearing nodules on their roots could develop satisfactorily in artificial soils containing only the merest trace of nitrogen, provided that the mineral elements necessary to plant growth were present. It was afterwards found that the nodules resulted from the proliferation of the root tissues following the invasion by bacteria from the soil, and finally, in 1888, Beijerinck succeeded in isolating the nodule-forming organism and growing it in artificial culture.

The bacteria living in the nodules on the roots of leguminous plants are able to obtain nitrogen direct from the atmosphere which pervades the soil in the neighbourhood of the roots. The bacteria combine the nitrogen with other substances, and these later are absorbed by the host plant. When such plants are ploughed in, or when they are fed to animals and the manure from them is returned to the soil, the result is a definite gain in nitrogen obtained from the inexhaustible supplies of the atmosphere. The same effect is produced by leguminous shade trees whose leaves and twigs are constantly being shed upon the surrounding soil.

Abundance of nodules on the roots of leguminous crops grown as green manures enables them to make good bulky growth for ploughing under. It also leads to the production of vigorous root systems which are thus able to draw on a large volume of soil for their minerals. Indirectly, therefore, a further advantage may be conferred upon the succeeding crop by the accumulation in the surface layers of the soil of minerals brought from greater depths. Nodulation may also greatly increase the protein content of legumes used as fodder.

Varieties and Strains of Legume Bacteria.

Since the fact that bacteria in the nodules on the roots of leguminous plants are able to fix atmospheric nitrogen was established, it has been found that those which produce nodules on the roots of any particular legume are by no means necessarily able to do so on the roots of other members of the family. It has been discovered, in fact, that a number of varieties of the nodule bacteria exist and

that leguminous plants can be divided into several groups between which the bacteria are incapable of causing cross-inoculation. Thus, for example, the same variety of nodule bacteria will infect field and garden peas, vetches, lentils, and some other legumes, but will not inoculate members of the lucerne group, which includes sweet clover and trefoil. About twenty such "cross-inoculation" groups are now recognized, and of these the principal ones in which the Kenya farmer is interested are given in Table I, where Carroll's system of classification has been adopted.

TABLE I.

CLASSIFICATION OF A NUMBER OF CROP PLANTS ACCORDING TO THEIR CROSS-INOCULATION GROUPS.

I.—Cowpea Group.

Arachis hypogœa—Groundnut.
Cajanus indicus—Pigeon pea.
Canavalia ensiformis—Sword bean, Gotani bean.
Crotalaria spp.—Several local species.
Desmodium spp.
Dolichos biflorus—Horse gram.
Dolichos lablab—Njahi.
Glycine hispida—Soya bean.
Lespedeza spp.
Mucuna utilis—Mauritius bean.
Phaseolus aconitifolius—Mat bean.
P. acutifolius—Tepary bean.
P. lunatus—Lima bean.
P. mungo—Green gram.
P. radiatus—Black gram.
Pueraria thunbergiana—Kudzu vine.
Stizolobium deeringianum—Velvet bean.
Vigna catjang; V. sinensis—Cowpea.

II.—Field Pea Group.

Cicer arietinum—Chick pea.
Lathyrus spp. including New Zealand and wedge peas.
Lens esculenta—Lentil.
Pisum sativum—Pea.
Vicia angustifolia—American vetch.
V. atropurpurea—Purple vetch.
V. faba—Broad bean.
V. sativa—Common vetch.
V. villosa—Hairy vetch.

III.—Clover Group.

Trifolium alexandrinum—Berseem clover.
T. hybridum—Alsike clover.
T. incarnatum—Crimson clover.
T. pratense—Red clover.
T. repens—White clover;
and many other species.

IV.—Lucerne Group.

Medicago sativa—Lucerne.
M. denticulata—Bur clover;
and several other *Medicago* spp.
Melilotus alba—White sweet clover.
M. officinalis—Yellow sweet clover.
Trigonella Foenumgraecum—Fenugreek.

V.—Lupin Group.

Lupinus angustifolius—Narrow-leaved blue lupin.
L. luteus—Yellow lupin.
L. perennis—Perennial lupin.
Ornithopus sativus—Serradella.

VI.—New Lupin Group.

Lupinus diffusus.
L. villosus.

VII.—Garden Bean Group.

Phaseolus angustifolius.
P. multiflorus—Scarlet runner bean.
P. vulgaris—Kidney bean, haricot bean.

VIII.—Lotus Group.

Lotus corniculatus—Bird's-foot trefoil.
Anthyllis vulneraria—Kidney vetch.

IX.

Dalea alopecuroides—Wood's clover.

X.

Onobrychis sativa—Sainfoin.

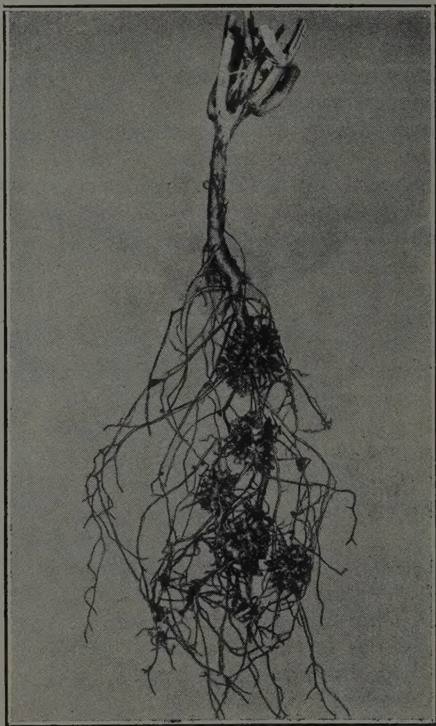
It is necessary at this point to state that, while cross-inoculation does not take place between the members of different groups, it is not safe on the other hand to assume that it will occur

with uniform efficiency between the members *within* a group. Although, in general, the bacteria from one host plant will cause nodulation on other members of the same group, they may not do so equally vigorously in all cases. It has been found in fact that, within the same cross-inoculation group, the bacteria infecting the different host plants may consist of a number of strains varying in virulence. Evidence of this can be seen particularly in Group I in Table II, given later, which exhibits considerable variation in the degree of nodulation found in the same district. This group includes the extreme case of the soya bean, which until fairly recently was always placed in a completely independent group of its own. The discovery in America that, under certain special conditions, the bacteria from soya bean can produce nodules on cowpea led, however, to the inclusion of the former in the cowpea group. The fact still remains, nevertheless, that, in Kenya, whereas cowpeas produce nodules fairly readily without inoculation, the strain of bacteria concerned appears to be incapable of infecting soya beans.

To sum up the situation, it may be said that whereas no cross-inoculation can be expected between members of different groups, there is a likelihood, but not a certainty, that when a leguminous crop immediately succeeds another well-nodulated crop of the same group, the second will develop nodules also.

Whenever nodules fail to develop on a leguminous crop, or do so only feebly, or whenever there is reason to suspect that they may not do so, the next crop of the kind to be sown on the land in question should be inoculated with the appropriate strain of bacteria.

The nodule bacteria in the soil tend to die out in the absence of the normal host plant, especially in acid soils. If therefore more than a year or two has elapsed since the land carried the same leguminous crop, or one of the same cross-inoculation group, it is very likely that inoculation will prove beneficial.



Groups of Nodules on roots of New Zealand grass pea. (*Grown at Scott Agricultural Laboratories, Nairobi*)

This is also true if the crop is to be grown on new land. Where land is excessively acid, liming will generally benefit both the bacteria and the host plant.

Methods of Inoculation.

There are two main types of procedure by which nodulation of a leguminous crop can be brought about. These are—

(*a*) by adding soil from land known to be rich in the required strain of bacteria to that in which the crop is to be sown; and

(*b*) by means of artificial cultures of the bacteria.

The soil method was the more popular in the early days, when disappointing results were often obtained from the use of cultures in which the nodule bacteria were distributed on unsuitable media or without sufficient regard to the necessity for providing virulent strains of the organisms.

In using the former method the soil must be top soil obtained from a field which is known to have borne a well-nodulated crop of the same kind or of the same cross-inoculation group as that to be sown. It may simply be broadcast and harrowed in, or it may be mixed and sown with the seed in the drill.

For broadcasting, it is impossible to lay down definitely the amount of soil required, as this depends so largely on the number of nodule bacteria which it contains. 300 to 500 lb. per acre, however, is about an average quantity to use. For mixing with the seed, recommendations vary from sufficient soil to make the seeds dirty to equal quantities of soil and seed.

The soil transfer method is cumbersome and generally expensive, unless the distance involved is quite small. There may also be some danger in certain instances of introducing new diseases, pests or weed seeds into areas where they do not already occur.

The use of artificial cultures of the strain of bacteria required has now become an established practice. In the United States the number of cultures used annually considerably exceeds one million.

The most usual form of culture consists of a bottle containing a jelly-like substance, agar, with which are incorporated various nutrient substances suitable for the growth of the bacteria. The latter, obtained by a special bacteriological technique from a nodule of the particular crop concerned, are "planted" on the surface of the medium, where they develop and multiply to form a slimy growth, consisting eventually of billions of the individual organisms. Some manufacturers employ various other types of medium, such, for instance, as sterilized soil or peat.

Directions for use are usually given with the culture. The essential requirement is to transfer as much as possible of the slimy bacterial growth from the culture to the surface of the seed which is to be sown. The bacteria are thus brought into close proximity with the developing roots of the seedling which they are required to infect. In the usual method employed, a quantity of either water or skimmed milk is poured into the culture and shaken vigorously to detach the bacteria from the medium and bring them into suspension in the liquid. To obtain the greatest possible number of bacteria from the culture, the process should be repeated with successive small quantities of liquid, which can all be mixed together in one receptacle as they are poured from the culture. In general, cultures are designed to treat about a bushel of seed, and for this purpose round about one pint of the liquid suspension will be required. Many manufacturers recommend sweetening the suspension with sugar (a tablespoonful to a pint), while, for lucerne, the Rothamsted Research Station in England advises skim milk, to which 0.1 per cent of soluble calcium phosphate has been added, as the inoculating fluid. If the calcium phosphate is not readily obtainable, basic superphosphate, at the rate of a quarter teaspoonful to a pint of skim milk, can be substituted.

The milk or water suspension of bacteria is sprinkled on and thoroughly mixed with the seed on a clean floor, after which the seed is spread out to dry, and should be sown without delay. Bac-

teria will probably persist in viable condition for some weeks in storage, but their numbers gradually diminish, and the best results will be obtained with the least sowing delay. In the same way, the bacteria in the original cultures also slowly die out as food supplies become exhausted, and manufacturers therefore often state on the label a date later than which the cultures are unlikely to be satisfactory for use.

Stocks of cultures suitable for cowpeas, lima beans, velvet beans, field and garden peas, vetches, soya beans and lucerne are frequently obtainable from the Kenya Farmers' Association, Nakuru, at a cost of Sh. 10/50 per culture. Outside Kenya the nearest source of supply is probably South Africa, where, according to a list kindly supplied by the Union Department of Agriculture, the following firms stock legume bacteria:—

M. Edelman, Agricultural Adviser, Cedarville, E. Griqualand.

Messrs. C. Stark and Co., Mowbray, Cape.

Messrs. Commercial General Agency, 171 v. d. Walt Street, Pretoria.

Messrs. A. Ford and Co., 29 Gouch Street, Johannesburg.

Experiences with Nodulation in Kenya.

Table II, compiled from reports of Agricultural Officers, indicates what degree of nodulation has been observed on a number of leguminous crops on Departmental plots in various districts.

(*See Page 13.*)

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TABLE II.

Group	Crop	District: Nairobi	Rongai	Molo	Njoro	Kitale
I	Cowpea ..	Moderate	Present	—	Present	For the group generally, except soya bean, inoculation unnecessary.
	Black Mauritius bean (*Mucuna utilis*) ..	Sparse	—	—	—	
	Lespedeza ..	Fair	—	—	Moderate	
	Groundnut ..	—	Present	—	—	
	Velvet bean ..	Sparse	Doubtful	—	—	
	Njahi (*Dolichos lablab*) ..	Moderate	—	—	—	
	Soya bean ..	Inoculation essential	Inoculation probably essential	—	Inoculation probably essential	Inoculation probably essential
II	Field pea ..	Good	Poor	Plentiful	Poor	For the group generally, inoculation unnecessary though possibly beneficial at first.
	Garden pea ..	Good	—	—	Poor	
	Sweet pea ..	—	—	Plentiful	—	
	New Zealand grass pea ..	Very good	—	—	—	
	Wedge pea ..	Very good	—	—	—	
	Lathyrus ochrus	Fair	Plentiful	Plentiful	—	
	Horse bean ..	—	—	Plentiful	—	
	Vetch	Present	Plentiful	Plentiful	Poor	
III	Clover	Moderate to good	—	Abundant	Present	For the group generally, inoculation unnecessary.
	Wild clover (*Trifolium Johnstoni*) ..	—	Present	—	—	
IV	Lucerne ..	Poor	Present	Present	Present	Inoculation probably needed.
	Bur clover ..	Present	—	—	Present	
	Hubam clover .	Fair	—	—	Present	
	Fenugreek ..	—	—	Present	—	
	Sweet clover ..	Fair	—	Present	—	Inoculation probably needed.
V	Lupin	Good	Poor	—	Abundant	Inoculation needed.
	Serradella ..	—	—	Present	—	
VII	Garden and field beans ..	Fair to good	—	Plentiful	Present	Inoculation unnecessary.

Measures Against Soil Erosion in Tanganyika Territory

By E. HARRISON, *C.M.G., M.S.A., B.Sc., N.D.A.,*
Director of Agriculture, Tanganyika Territory.

The photographs reproduced are part of a series from the Lubaga Experiment and Seed Multiplication Station, Shinyanga. This area is subject to wind erosion, sheet erosion and gully formation. One of the simplest methods of combating erosion on slight slopes is by the contour ridge *mtuta.* This, in native agricultural practice, should not be continuous, but the furrow below the ridges should be filled in at intervals of 10 feet or so in order to prevent flow, as it is likely that the furrows will have a fall in one direction or another.

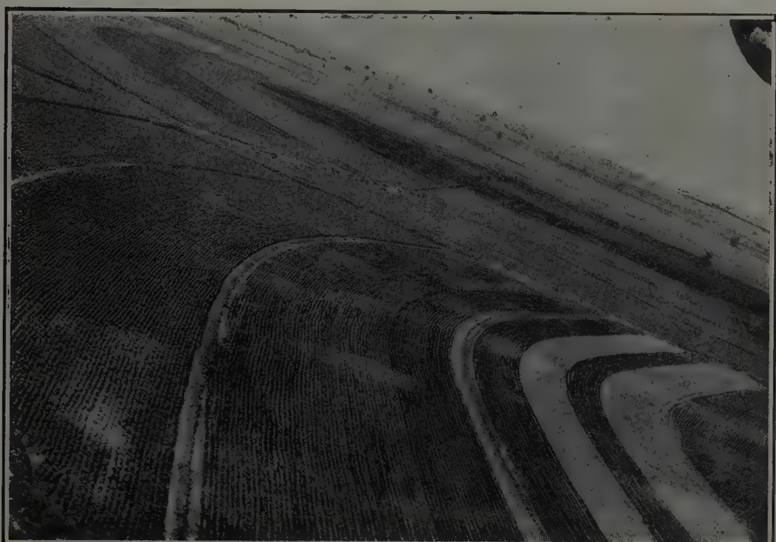
Another method is to make a criss-cross, making the land look as though it were evenly pitted all over. The pits should be large enough to hold two inches of rain. Thus they might be 6 ins. to 8 ins. deep and 4 ft. wide. They have to serve an area of 16 sq. ft., thus each pit should have a capacity of, say, 3 cubic ft. This means, for pits 6 ins. deep, that they should be about 2 ft. across at the bottom. Such work, if well done, should hold any downpour.

It is important that a storm drain be cut above any lands so treated if there is higher ground behind from which a sheet of water may flow. Another simple matter is to get natives to hoe banks on the contour, lifting the soil up the slope. If these banks are made not more than 4 yds. apart, it is surprising how they hold up the rain and the wash, and in due course assume the feature of a terrace.

With hills, it is wise to make a high contour bank all round near the top, and not allow cultivation above such a bank. It should be planted with cassia or other trees, and within a few years the land between the belt and the scrub on the hilltop will be protected.

A Contour Bank. On the left a field of Virginia Bunch Groundnuts, planted on ridges 3 ft. apart; 2 rows per ridge, 8 ins. in row. On right, Barberton o/4 bulk cotton.

Contour Bank. Inter-row cultivation of cotton with Planet Junior cultivators. Damage to cotton due to termites. Bulrush millet in background.



Aerial Photograph illustrating Contour Planting and Inter-row Cultivation.

Overstocking in Kenya

The following article is the first of a series on overstocking in East Africa. The position in Kenya Colony was ably examined by the Kenya Land Commission in 1932-33. In their Report the Commission described the position created by the uneconomic accumulation of live stock in the native reserves, and made proposals to ameliorate what they describe as a preposterous state of affairs. Their findings were recorded after hearing evidence from every variety of opinion.

At the beginning of the century, cattle in Kenya Colony were comparatively few owing to a series of disease epidemics during the previous two decades, but with the introduction of veterinary control measures under the British administration the cattle population increased to an estimated total of 3,000,000 in 1920, and to 6,000,000 in 1932. Whereas in 1900 the grazing was more than ample to supply the needs of the cattle, and in 1920 the signs of overstocking and consequent deterioration of land were hardly noticeable, by 1932 large areas where there used to be grass had been replaced by thorn scrub or reduced to bare earth, and the soil washed away by gully and sheet erosion. The optimum carrying capacity of the native reserves was probably reached in 1920, since when the cattle population has doubled.

As the overstocking problem is the direct result of British rule, there is an obligation upon Government to devise adequate remedies. Despite the apparent wealth of the natives in pastoral and semi-pastoral areas they are in fact suffering real poverty. A human population of under 3,000,000 owns about 6,000,000 cattle, and probably many more sheep and goats. Many of them consume little or no milk and insufficient meat. Many cows do not produce enough milk to feed their calves, and the annual sales to outside markets do not exceed 20,000 cattle and a negligible amount of ghee. In some areas the cattle have notably deteriorated both in size and in milk-yielding quality. In addition, there is a lamentable waste of valuable material in Kenya because, when an increase in the cattle population is followed by a bad year, the whole of that increase die, and many carcasses are left to rot on the veldt.

The position in Kenya may be contrasted with that in Australia, who with less than twice the number of cattle than there are in Kenya exports millions of pounds of beef, butter and cheese. There is, however, a similarity of conditions in Kenya with those obtaining in the native reserves of South Africa. Kenya is considered fortunate to the extent that overstocking is of comparatively recent growth, and the damage caused is not yet irreparable, provided that prompt remedial measures are introduced. Delay will allow the reserves to be irretrievably ruined and their inhabitants reduced almost to starvation. With stock increasing at compound interest, the grass is denuded and the soil destroyed at an ever-increasing rate. Firm and early action is necessary to deal with this grave and urgent problem.

The solving of this problem would bring much wealth to the native inhabitants. The native reserves of Kenya contain some of the finest dairy land, capable of supplying native requirements of meat and milk, and of producing large quantities of dairy produce for export, thereby adding not only to their own wealth but to that of the Colony. If the native cattle-owners were to adopt

the management methods with which the intelligent European farmer develops his land, there would indeed be a prosperous future for the reserves. The lands would carry more stock and of better quality. Disastrous losses from drought would not recur. The pastoral native would then have the money which he now lacks for the purchase of grain and the improvement of his soil and pastures. Government would indeed be fulfilling their trust in the guardianship of the natives.

The Commission, whilst realizing the difficulties, recorded their opinion that a clear and definite policy should be laid down by Government on comprehensive lines, and must have as its main consideration the fact that there is a definite relation between the area of land and the stock which it can support. This policy would at first be unpopular, because the ownership of stock is so interwoven with native habits and customs—the owners regarding stock as currency and not as a productive asset. The urgency of action against overstocking has been pressed for many years by committees and commissions, notably Sir Daniel Hall's Agricultural Commission which reported in 1929, but no effective action has been taken, although provisions for enforcement are available in the Crop Production and Live Stock Ordinance which was introduced in 1926.

The Commission appreciated how much better it would be if the natives could be made to understand the necessity for destocking. It has been urged that it would be best to wait until, by education, the consent of the natives has been won, but the Commission were of the opinion that many years would be required for such a process, by which time, the pastures being ruined and the quality of stock deteriorated, any action would be too late. The custom under which large numbers of native cattle are held in trust, whereunder several persons have an interest in each beast, precludes the possibility for some years to come of securing consent to the culling of stock. A policy of culling would involve difficulties and not be popular, but in the opinion of the Commissioners, and of several senior administrative officers, would be found practicable. The material position of the natives would be improved from the start, even though they received only four or five shillings for each culled beast, the food supplies of the pastoral tribes would not be detrimentally affected, and the amount of stock available for a marriage transaction would still be adequate. Characterizing inaction as mistaken kindness, the Commission recommended, with all the emphasis at their command, that the culling of surplus stock should be undertaken with the least possible delay.

Proposals for Amelioration.

The Commission considered that the problem was definitely not one which could be solved by an increase of land, though in certain cases some additions were necessary on economic grounds and in order to recondition devastated areas. Natives should be educated in better methods of animal husbandry, the economic use of their land and stock, and the evils of overstocking. Although not neglected in the past, this education should be pressed forward more intensively. The natives must be taught to limit the numbers of their stock to the carrying capacity of the land, to improve the land and the quality of their cattle, to change the superstitious outlook towards their stock and to regard them more as an economic asset. Communal grazing should be controlled and gradually superseded by private tenure, and meat markets should be

fostered. In this work much can be accomplished by Administrative Officers working through the Local Native Councils, by Agricultural Officers, Veterinary Officers, and even the Education Department.

The prevalence of tsetse-fly over large areas is an important factor which causes over-concentration of stock in the other parts of the reserves. Bush clearing for the eradication of the fly would ease the overstocking problem by extending the grazing areas and so enable other parts of the reserve to be rested. Such a system of bush clearing has proved successful in Tanganyika Territory, and was advocated by the Commission for adoption in Kenya.

The Veterinary Department has devoted itself to the eradication of stock diseases, and a corollary of this has been the imposition of quarantine restrictions, which, in the opinion of the Commission, has restricted sales of cattle outside the reserves and accentuated the overstocking problem, most of the native reserves having been kept in perpetual quarantine. The Agricultural Commission of 1929, after emphasizing that such quarantines handicapped the progress of the stock industry and doubting if the regulations had been successful or even enforced properly, recommended that the quarantine regulations should receive consideration with a view to the freer movement of cattle and the provision of stock routes. The Land Commission had no information as to what measures had been taken, but recorded their view that it was most necessary to permit freer movement from the native reserves and to provide stock routes.

Although the imposition of a stock tax has much to recommend it, several factors would militate against its effectiveness in dealing with the overstocking problem: absence of markets, difficulty of accurate counting, constant movement in search of grazing, and the native method of keeping stock in several places. A native would also prefer to sell a small number of his best stock at a good price than a large number of inferior stock at a poor price. The Commission, however, did not rule out future consideration of a stock tax, but advocated a system of culling which in time should be superseded by a stock tax. This tax should not be imposed directly to deal with the overstocking problem; it should be payable in cash, and the revenue derived from it should be used for the benefit of natives.

The Crop Production and Live Stock Ordinance, 1926, provides for limiting the number or kind of stock in any area, promoting improvement of quality, and for the disposal of surplus and undesirable types, but these provisions have not been applied. The Commission considered that the Ordinance should be gradually applied, and be employed primarily in areas in which devastation is taking place rapidly and where educational methods are likely to be slow in their effect. In the first place the culling should be limited to all lame, blind and decrepit animals, and in succeeding years be progressively severe to all redundant male animals and uneconomic beasts. Natives should be given an opportunity of selling or eating the culled animals, but should they be unwilling to do so, or numbers render this impossible, animals of poor and bad types should be disposed of by slaughter or removed to the nearest market or fertilizer factory, payment being made in cash or by credit ticket redeemable at the local District Commissioner's office. It was suggested that an arrangement should be made with the natives for a portion of the cash proceeds to be paid to a fund for the purpose of reconditioning, paddocking, fencing, and general improvements in the relative reserves.

Even with the moderate culling proposed in the initial stages, the number of cattle slaughtered would be considerable. Assuming that culling were applied to half the number to the extent of 7½ per cent of the 6,000,000 native cattle in Kenya, some 225,000 a year would have to be slaughtered, many of which would be unsaleable or unfit for food. Consequently there arises the question of fertilizer factories for the preparation of blood, meat and bone meals, curing of hides, and the preparation of dried meats. The Commission emphasized that fertilizer factories must be an essential corollary of any measures taken to deal with the overstocking problem, and considered that a factory should be a paying proposition, because the price paid for an animal would only be a few shillings or its economic value, and because there would be an increasing demand for fertilizer products, and the preparation of hides for export would be a profitable undertaking.

Although no loss should be incurred, the Commission considered that a State subsidy would be justified, because the question was not whether the Colony could afford to have a meat factory but whether it could afford to be without one. The interests of the producer should be protected, and he should receive as good a price for his stock as possible, depending on the prices realized for fertilizers, which should be fixed to secure sales in the whole East African market. This project could best be undertaken by a public utility company, over which the State would exercise control, a percentage of profits being credited to the Native Betterment Fund to be earmarked for the development of pastoral reserves. If no such company were available, Government itself should operate the necessary factories.

The damage caused to grazing areas by sheep and goats is greater even than that caused by cattle. The culling problem of sheep and goats is a difficult one, as there is probably no market to absorb the large numbers, and their value to a fertilizer factory would be small. A tax would be difficult to assess, and would be strongly resented by the natives. Sheep and goats are necessary for food supplies to the natives, and in many areas they are the only live stock which thrive, and do little damage. Culling was necessary in certain locations, but, in general, steps should be taken to confine sheep and goats to certain areas where they can do the least damage.

On European farms there are large numbers of squatter cattle, sheep and goats, out of all proportion to the requirements of the natives. A system of Kaffir farming is prevalent, and the abuse far outweighs any benefit. A strict limitation should be imposed on the number of squatter stock which the resident labourers are allowed to have on farms. As the return *en masse* of all excess squatter cattle would increase the overstocking problem in the native reserves, consequently a policy of gradual reduction should be adopted. This policy should not be left to local option.

Finally, the Commission advised that a committee should be appointed to inquire into the matter in greater detail. Early action is necessary in order to deal with a situation which gravely threatens the whole future of the native lands of Kenya. The future needs of the natives and the prime need for the conservation of their estates clearly depend on the firm adoption of adequate remedial measures.

The Introduction of Sugar Cane Varieties into Uganda

1926-1934

By C. G. Hansford, *M.A., F.L.S.,*
Mycologist, Uganda.

At the time of my arrival in Uganda in October, 1926, the Uganda sugar industry was still in what may be termed its initial stage. Lugazi factory was still being enlarged, and was not working at full capacity. The cultivation on that estate was then about 1,500 to 2,000 acres, and was planted with any cane which was available, irrespective of variety. The predominating variety was "Striped Ribbon", which was generally a very successful sugar producer under the conditions then in force. Yields of up to 100 tons per acre had been recorded from very good land, and it was estimated that the average yield for well planted and cultivated fields was in the neighbourhood of 55 to 60 tons per acre. The sugar content of the canes was up to the standard set by other cane-growing countries, and rarely fell below this, even in wet seasons. Altogether it was evident that only particularly good canes stood any chance of showing any improvement over this old cane, which had been abandoned years ago in all other sugar-growing countries in favour of newer canes, such as "Crystallina" (White Transparent) in the West Indies.

Other varieties then in existence on Lugazi Estate were the following:—

"Black Tanna": A short-jointed, very thick cane, giving fair tonnage but poor juice.

"Striped Tanna": With a record similar to the above.

"Seeley's Seedling": A thinner cane than the Tanna varieties, with longer joints, and generally higher sugar content. This variety suffered from the disadvantage that in wet weather there was a pronounced tendency for the "eyes" along the cane to grow out, producing side shoots, and accompanied by a great reduction in the sugar content of the cane.

"Uba": This was found to take about four months longer to mature than "Striped Ribbon", contained less sugar in the juice, had a very high fibre content, the trash adhered very closely to the mature cane, and was expensive to remove; the cane was very hard, and caused great difficulty in milling and boiling in the factory. Altogether this was regarded as a very inferior variety, except for "murrum" soils, on which other varieties would not grow.

A number of imported varieties from Java and Ceylon were also grown at Lugazi, but little attempt had been made to sort them out; in any case, the original labels had been lost, and identification was impossible.

At the time of my arrival, steps were being taken at Lugazi to sort out the various canes grown there, and to compare them for yield and sugar production. The general conclusion reached some little time later was that none of the other varieties then grown could compare with "Striped Ribbon" as general purpose canes. It was decided therefore to abandon all these miscellaneous varieties, and to concentrate on "Striped Ribbon", save for "Uba", which was grown on patches of land where "Striped Ribbon" would not do well.

On reviewing the position, it became evident that if the industry were to make

the best use of its natural advantages other improved varieties must be imported, as it was considered very dangerous to rely solely on "Striped Ribbon", especially in view of the fact that mosaic disease had been found in quantity in Kenya, and would probably occur in Uganda within a short time. At the same time, great extensions of the cultivation area were contemplated, and it was therefore considered best to import a number of standard varieties from the West Indies, in the hope that some of these might prove better sugar-producers than "Striped Ribbon", and by rapid propagation of such, considerable time and expense might be saved, by dispensing with further extensions of unprofitable varieties.

Arrangements were therefore made to import a collection of standard varieties from Jamaica, where it was known that a nursery of such existed, comparatively free from disease infection. As mosaic had not then been discovered in Uganda, it was of the utmost importance to ensure that it was not imported with the new varieties, especially as experience with "Striped Ribbon" elsewhere indicated that it was likely to be extremely susceptible under Uganda conditions. Hitherto we have been very successful in avoiding the introduction of diseases into Uganda on the new cane varieties, the only possible exception being "Red Stripe", and this is a very doubtful exception. In view of the risks from mosaic disease, it was decided to import a number of varieties known to be almost immune to the disease, so that, should it appear at any time, stocks of such varieties would be immediately available. Such varieties were obtained through the courtesy of Dr. E. W. Brandes, of the United States Department of Agriculture, Washington. The ordering of these last varieties was particularly fortunate, as soon after their arrival mosaic disease was found at Lugazi, while all the newly imported canes were still in quarantine at Kampala.

The new varieties arrived as two to four cuttings of each, and were planted in a piece of swampy land on the Government Plantation, Kampala, which was drained by surface drains. In spite of the prognostications of many people, this land proved eminently suited to the canes, which grew remarkably rapidly. As soon as the young plants were sufficiently developed, all shoots with more than three joints were cut out from the roots and planted in other beds for propagation. This process was repeated from time to time, with the object of developing stocks of each variety as soon as possible. All plants were under constant observation for the appearance of disease, but none appeared. At the end of 1928 sufficient material was available to plant out larger beds of each variety, and by this time it was evident that some of the varieties were much more vigorous than others. As, however, all propagation had been carried out on rather swampy soil, all varieties were further propagated, as it was considered that the less vigorous types might possibly prove more suited to the hillside lands at Lugazi.

During 1929 the stocks of these varieties had become sufficient to supply to Lugazi Estate. All were planted in a replicated variety trial there for observation. During the course of their growth several contracted mosaic disease in very severe form, and were therefore discarded as being unsuited to conditions there. The mosaic resistant varieties P.O.J. 2725 and 2727, as well as the "tolerant" P.O.J. 213, gave very good results, and it was considered best to propagate these as rapidly as possible, rather than to leave them to mature to obtain yield figures. At this time mosaic disease was beginning to show signs of very rapid dissemination on "Striped Ribbon" in many parts of

the estate, and it was recognized that, at best, roguing was only a palliative and temporary measure in the control of this disease, until such time as more resistant varieties became available in quantities sufficient to plant on a larger scale, provided always that these gave sufficient tonnage and proved satisfactory in the factory.

The first of the new varieties to be planted on a large scale was P.O.J. 213, on a stony hillside of rather poor land. This was an experiment to see how this variety compared with "Uba" under similar conditions. The result was that P.O.J. 213 was abandoned completely, chiefly because it became 100 per cent infected with mosaic; but also because its yield showed no improvement on that of "Uba".

Meanwhile, P.O.J. 2727 and P.O.J. 2725 were being propagated as fast as possible, the former being considerably ahead in acreage. The first cane to arrive at the factory for grinding was in 1931; it was found that P.O.J. 2727 was decidedly inferior to P.O.J. 2725. In consequence, further extension of P.O.J. 2727 was retarded in favour of that of P.O.J. 2725, and up to the time of writing the latter has developed into the standard cane on both large estates in Uganda. To-day very little "Striped Ribbon" remains in Uganda. Side by side with the propagation of these varieties on Lugazi Estate, the area of cultivation was extended to some 6,000 acres.

Meanwhile, attempts had been made to introduce other varieties resistant to or tolerant of mosaic. P.O.J. 2878, the "wonder cane" of Java, and E.K. 28, were introduced direct from Java, but further introductions from this source have been stopped by the action of the Java authorities prohibiting the export of P.O.J. canes to other parts of the world. A series of P.O.J. canes and two Indian varieties were obtained from Natal in 1933, and this was the last importation made direct into Uganda. Since then, arrangements have been made for the importation of new varieties through the Amani Research Station.

It must be realized that sugar cane is not imported as seed, but as cuttings, and the risk of importing disease in such is very great. Also, some of the sugar cane diseases are very obscure in their symptoms, and descriptions are not always accurate; so that there is considerable risk that a disease may be missed until such time as someone with a personal knowledge of it happens to see the canes. The classic example of the importation of a disease which remained undiscovered in this way is that of mosaic disease in the West Indies. It was eventually described as a new disease of sugar in 1918-19, but on comparison with the descriptions in Java it was afterwards found to be the same as the mosaic disease known there for some twenty years, and almost certainly imported from Java to the West Indies, either direct or via Hawaii. Mosaic has now become of less importance, owing to the development of a number of resistant varieties of canes; but there are other diseases in the East to which none of the varieties cultivated anywhere in the world are resistant or immune, and the risk of importing these diseases is increased with every increase in the number of cuttings of cane imported.

In view of these considerations, it is essential that new importations be made on a very small scale, and be limited to varieties of which there is a reasonable chance that they may be valuable to local planters. We cannot afford to take the risk of importing large numbers of varieties and from these select the best. During the first year or two, all propagation must be carried out on a site far removed from other sugar cane cultivations, at least from commercial estates.

Regular inspection of the canes at all stages of growth is of the utmost importance, and any canes showing the slightest signs of any new disease are ruthlessly destroyed.

The following paragraphs contain notes on some of the more important of the recent importations, with their behaviour under Uganda conditions:—

P.O.J. 2725.

This has proved to be the best cane at present grown in Uganda. Originally introduced here from Washington in 1927, it now covers some 4,000 to 5,000 acres. It grows rapidly and tillers well; the canes are rather short and thick as compared with its relation, P.O.J. 2727. It matures very early, at 12 to 14 months, but suffers from the disadvantage of early flowering or "arrowing". Cases have occurred of its flowering as early as nine months after planting. On the other hand, I am informed by the staffs of Lugazi and Kakira Estates that it can be left in the field for at least two months after flowering before any noticeable reduction in sucrose content takes place. Its tonnage is higher than that of other canes planted here, and its sugar content fair to good. It is becoming evident that this variety is well suited to Uganda conditions, and that only an exceptionally good cane is likely to beat it as a sugar producer. The yield at Lugazi, averaged over all types of land and including both plant and ratoon crops, is some 45 tons per acre.

This variety appears to be immune to mosaic in Uganda; no case has been observed to date. It is more resistant to Red Stripe disease than P.O.J. 2727 and 2878, and does not appear to suffer to any extent from other diseases present here.

P.O.J. 2878 (Java Wonder Cane).

This became famous about 1928-29 through the reports of visitors to Java, where it undoubtedly was responsible for a considerable increase in sugar yield per acre. It was introduced from Java into Uganda in 1929, and issued to estates in October, 1930. Experience here has indicated that under Uganda conditions it is not likely to repeat its record in Java. Here, it is decidedly a long season cane, and in spite of its high sugar content, its production per acre does not compensate for its long growing season as compared with P.O.J. 2725, which gives an extra cutting every four years.

A few cases of mosaic have been noticed on this cane in Uganda, but the disease is never likely to be of economic importance on it. The variety is, however, decidedly more susceptible to Red Stripe than P.O.J. 2725; and recently a number of cases of "top rot" have occurred on it. To other diseases in Uganda its resistance is similar to that of P.O.J. 2725.

P.O.J. 2727.

Introduced from Washington in 1927, it proved more vigorous in growth than P.O.J. 2725, so that by the end of 1930 it covered a larger acreage than the latter. Since then it has declined in favour, as it was found of inferior quality to P.O.J. 2725. It takes 16 to 18 months to mature, and can be left even longer in the field. The mature canes, however, tend to be pithy and hollow, and the juice is of rather poor quality.

This variety is definitely the most susceptible of the P.O.J. canes grown here on a large scale towards both mosaic and red stripe diseases. To other diseases its resistance is similar to that of the two varieties mentioned above. It is a very erect cane, and sheds its trash easily, so that it is a very cheap cane to harvest.

P.O.J. 2714.

Introduced in 1928, it proved rather inferior to the above varieties in the nursery stages. Owing to theft of labels, the stocks of this became mixed, and were subsequently discarded.

P.O.J. 213.

Imported in 1927; it is a thin purple cane with a very large number of canes to the stool. At Lugazi it became 100 per cent infected with mosaic. As it was no better than "Uba" on poor lands, and decidedly inferior to P.O.J. 2725 on good lands, it was discarded.

P.O.J. 2379.

Introduced in 1927; it is a much thicker cane than P.O.J. 213. It suffers from the same disadvantage of being very susceptible to mosaic infection, though the tonnage does not appear to be much affected by such infection. It was discarded in favour of P.O.J. 2725.

BH. 10/12.

Introduced from Jamaica in 1927. In the West Indies this is considered as one of the best varieties, especially on good land. Its sugar content is very high.

At Lugazi, this variety proved very susceptible to mosaic, and was practically killed out by it; it was discarded there in consequence. At Kakira, however, it has been found possible to control the disease by roguing out infected canes from the fields. On this estate the variety ranks high as a sugar producer.

Ba 11403; *Ba* 8409.

Introduced from Jamaica in 1927. Both varieties proved failures at Lugazi on account of mosaic infection; at Kakira they are still grown on a small scale.

Other Importations.

Ba 2001, Ba 11569, Ba 6032, SC 12/4, "White Transparent", all from Jamaica in 1927; since discarded.

R.P. 8 and other varieties from Mauritius in 1928; all discarded.

P.O.J. 2822, P.O.J. 2952, P.O.J. 2947, P.O.J. 2946, from Natal in 1933; just issued for trial on estates.

Co 281 and Co 290 from Natal in 1933. Both are very thin canes, and appear to be unlikely to give as good results as P.O.J. 2725 in Uganda; just issued to estates for trial.

Sugar Cane Diseases in Uganda

By C. G. HANSFORD, *M.A., F.L.S.,*
Mycologist, Uganda.

A.—Mosaic Disease.

This was first discovered on Lugazi Estate in 1927. At that time it was limited to about 100 acres of cane. The distribution of the disease indicated that it had probably been present for about a year, though inspection of the estate in late 1926 had failed to reveal it. No indication of infection of local grass weeds was found, and the origin of the disease in Uganda remains a complete mystery. It has since appeared on Kakira Estate, again of unknown origin, and, as far as present information is available, its distribution is still limited to these two estates and native cultivations close by them. No cases have ever been noticed in other districts, nor has any case ever appeared in the sugar cane nursery at Kampala, on either the older varieties or those imported since my arrival in 1926. It is therefore quite certain that the disease has not been imported on the newer varieties of cane; in fact it was found at Lugazi before any of these were grown there.

The disease is most easily diagnosed by the leaf symptoms. Instead of the leaves presenting a uniform dark green appearance, save for the veins and midrib, those of infected plants show a mottling or mosaic effect; a lighter yellowish green colour is distributed over the leaf area in patches, the extent of which depends upon the variety of cane attacked. Some varieties show just a faint mottling, the normal dark green colour predominating, but on other varieties the proportions of the two colours are reversed. In P.O.J. 213 the mottling is often very obscure, and some plants show no visible symptoms, although tests show they are infected. On some very susceptible varieties, white streaks appear in the centre of the lighter green patches.

In addition to the leaf symptoms, a varying amount of striping occurs on the canes themselves, though the stem symptoms are not as prominent as those on the leaves. On very susceptible varieties some splitting of the internodes occurs, leading to infection by various weakly parasitic fungi.

The damage caused by the disease is not very obvious, as most varieties of cane are somewhat tolerant of infection, and still continue growing in the field after becoming infected. Mosaic causes a loss in tonnage of cane, the extent of the loss varying with the variety of cane. The juice of infected canes is also somewhat reduced, as is the sucrose content of the juice extracted.

The varieties of sugar cane fall into the following classes in respect to their behaviour to mosaic disease:—

(i) *Immune Varieties.*—These include "Uba" and a number of thin Japanese varieties. All these canes are thin, hard, contain a very high proportion of fibre, and their sugar production is usually low as compared with other types. On the other hand, these varieties stand up well to adverse climatic conditions, and this renders them suited to areas on the edge of the sugar cane belt of the world; thus "Uba" is the mainstay of the South African sugar industry. In Uganda, "Uba" does better than other canes on "murrum" soils.

(ii) *Resistant and Tolerant Varieties.*—These include canes either very resistant to actual infection, or those

which suffer very little ill effects when infected. The varieties P.O.J. 2727 and 2878 in Uganda fall into this class, whereas P.O.J. 2725 is apparently immune in this country. To a certain extent, "Striped Ribbon" is tolerant in Uganda of mosaic infection; much more so than in the West Indies, where it suffers very severely when infected, and is there classed as one of the most susceptible canes.

(iii) *Susceptible Varieties*.—These include, under Uganda conditions, all the thick West Indian and Mauritius varieties, as well as the older types such as Tannas. Several of the recent importations from Jamaica were almost completely killed out by the disease at Lugazi; whereas, in their original home, they show much greater tolerance.

The most obvious method of control of this disease is to grow only immune varieties of cane, such as "Uba", which seems on the whole to be the best of such. This policy was adopted in Natal, where, before the disease became of importance, about 95 per cent of the total cane area was already under this variety. All other types of cane were eradicated, and after the disease had thus been cleaned up, a number of new varieties were reintroduced through quarantine.

The same policy was adopted in Kenya, where, however, the proportion of the total cane area under "Uba" was much lower than in South Africa, and, in consequence, the expense of eradicating other varieties was proportionately greater. In addition, "Uba" under Kenya conditions, as in Uganda, is classed as a poor sugar producer, so that the policy adopted resulted in an annual loss to planters by growing such a variety. Their mills and boiling houses were not at first adapted to dealing with pure "Uba" canes, and considerable expense was entailed in alteration of machinery to obtain satisfactory results in crushing this cane.

In Uganda, at the time of the discovery of the disease, there was very little "Uba" in existence, and it was considered complete waste of money to attempt to follow the policy of Natal and Kenya. It would have meant the destruction and replanting of about 90 per cent of the cane then growing in the fields, and replanting with "Uba", which from all points of view is definitely a very poor sugar producer under Uganda conditions. In fact, there is some doubt as to whether it might even have been preferable to allow the disease to go ahead without restriction on the "Striped Ribbon" then cultivated, as it was found by experience that even completely infected fields of this variety gave more sugar per acre on good lands than "Uba". After due consideration, it was decided to adopt a temporary policy of dealing with the disease on "Striped Ribbon", until such time as other more resistant varieties became available in sufficient quantity to replace this variety. Fortunately, a number of such varieties had already been imported before the discovery of the disease, and valuable time was thus saved.

The temporary measures adopted were the replacement of badly infected fields of "Striped Ribbon" by new plantings of the same variety, the utmost care being exercised to ensure that the "setts" for planting were taken from uninfected canes. The infected fields were allowed to mature, and were cut for the factory before being replanted. As soon as the young shoots of the new plantings appeared, gangs of men were sent round regularly, once every ten days, to rogue out any infected canes, and to replace them with healthy setts. This process of roguing was continued for some five

months after planting, after which the fields were left to mature. After cutting the plant crop, the ratoons were rogued free from mosaic in exactly the same way. By this means it was found possible to keep the areas of "Striped Ribbon" relatively free from mosaic, or at least to keep down the disease to an amount which could hardly be considered to affect yield. The roguing process was expensive, but not as expensive as digging out all canes other than "Uba", with the loss in production entailed by the growth of this variety.

Meanwhile every effort was being made to extend the P.O.J. canes, which proved almost immune from attack. By the end of 1930 some 300 acres of these had been planted, and from this stock the whole plantation was gradually replanted, these varieties being extended to replace "Striped Ribbon", as the latter was cut for the factory. The result was that by the end of 1932 mosaic disease was no longer an economic factor in sugar production in Uganda. On the whole the above policy has proved successful, and was attended by a minimum of loss and expense to the planters concerned. By its adoption it was found possible to keep fields of "Striped Ribbon" fairly healthy until their final replacement with P.O.J. canes; the sugar yields obtained during the interval being undoubtedly larger than those which would have been received had all canes been replaced by "Uba".

The present position is that, at Lugazi, where formerly mosaic had been an important disease and spread rapidly, the whole estate is planted with resistant varieties, chiefly P.O.J. 2725 and 2878, and the disease is now ignored completely. We are, however, limited for the future to canes possessing similar resistance to mosaic infection as the present P.O.J. varieties, as no attempt has been made at complete eradication of the disease. To date no susceptible varieties have given results at Lugazi comparable with "Striped Ribbon", so that the limitation referred to does not appear to be serious. In addition, most of the varieties being produced in Java and Barbados today are selected with a view to resistance to mosaic, as well as increased tonnage and yield. It would appear, therefore, that in the future a large number of such resistant varieties will become available, and should be tried out in Uganda. At present we are limited to at most three such varieties, and this position is by no means secure, as we may find at any time that these varieties become liable to other diseases or pests, rendering their further cultivation undesirable. We should therefore endeavour to obtain other varieties of similar resistance to mosaic, to act as a reserve in case of emergency.

B.—Red Stripe Disease (*Bacterium rubrilineans*).

This disease was first noticed in Uganda on P.O.J. 2727 second ratoons in the quarantine nursery at Kampala. The history of preceding crops from these roots, and of the material previously supplied from them to estates, indicated that it was practically impossible that this disease could have come into the country on the setts imported. There is every reason to believe that the disease originated on some local grass, probably *Pennisetum purpureum*, and thence spread to sugar cane. Stripes somewhat similar to these on sugar cane have been noted on this grass (elephant grass), but the causal bacterium has not been isolated from it as yet.

Since the first discovery of the disease, other cases have appeared on both Lugazi and Kakira Estates, in some cases in considerable quantity. From P.O.J. 2727 it has spread to other canes on these estates,

and to date P.O.J. 2725 appears to be the most resistant to infection, followed by P.O.J. 2878; P.O.J. 2727 appears to be the most susceptible of this series of varieties, which is fortunate, in that for other reasons it is considered inferior to the two others mentioned.

The disease appears chiefly on young plant cane and ratoon shoots, in the form of narrow, continuous, dark red to reddish brown stripes running longitudinally through the leaf blade from the base, and extending in some cases to the tip of the blade. The stripes follow the course of the veins, and the tissues of these are infected with the causal bacterium. The tissues between the infected veins are often pale in colour. Infected canes are checked in their development, especially when infection is severe, but later they appear to throw off the ill effects, and show almost complete recovery. Experience in Uganda and in other countries indicates that the disease causes little if any loss in crop. At the same time, care should be exercised to ensure that all setts for planting are taken from healthy fields, and, as far as possible, that no infected setts are planted. At Kakira Estate the disease has been almost completely eradicated by roguing out infected plants at the same time as those infected with mosaic disease.

C.—*Top Rot.*

A disease causing the rotting of the "tops" of growing canes has occurred from time to time in Uganda. The young leaves, still tightly rolled in the bud, become rotten and have a very offensive smell. A number of different bacteria and species of *Fusarium* have been isolated from such material, but no success has been obtained with inoculations with these, so that the cause remains unknown. The disease was first noticed in 1926, on the old Ceylon and Java varieties originally cultivated at Lugazi; after the abandonment of these varieties, the disease disappeared for some years until the cultivation of P.O.J. 2878 on a large scale. On this variety cases have recently been noticed, though they are not sufficiently frequent in occurrence to have any effect on the yield of the fields.

D.—*Root Diseases.*

These are practically non-existent in Uganda at present. Some years ago patches of cane at Lugazi were attacked by termites, on the roots and underground stem. Infection of the roots by some fungus was suspected, but no proof of this was obtained.

At Kakira Estate recently a few cases of rotting of the old leaf sheaths still attached to the cane were found, apparently due to a species of *Marasmius*, very like that associated with root disease of cane in the West Indies. Hitherto no effect upon the canes thus attacked has been noticed.

E.—*Leaf Spot Diseases.*

A number of these are known in Uganda, due to *Cercospora* and *Helminthosporium*. On some varieties, notably P.O.J. 213, P.O.J. 2379, Co. 281 and Co. 290, the spot due to *Cercospora* is very common, and at times almost covers the older leaves. As far as is known, the disease does not have any marked effect on yield, and in any case the first two of these varieties of cane have been completely abandoned for other reasons, while the two Co. varieties are recent introductions to Uganda and have not been tried out on estates.

The Cultivation of Lucerne

By R. S. BALL, *Dip. Agric. Sc.* (*Cantab.*), *A.I.C.T.A.* (*Trin.*),
Agricultural Officer, Kenya.

Introductory.

Lucerne has long been recognized in this country as a valuable food for stock, either fed in the green state, or made into hay, as a standby for the dry season. Considerable use has also been made of it for silage, but when used for this purpose it should, if possible, be ensiled together with some non-protein-rich material, such as oats, for, if ensiled alone, the high protein content may lead to the formation of a sour silage, due to the accumulation of butyric and other undesirable acids.

The crop forms an excellent food for all classes of stock, and can be fed with safety, although when used in the green state a certain amount of care must be exercised at first, particularly in the case of young stock, who should be introduced to it gradually, otherwise there is the danger of digestive disturbances, scouring, and even hoven, resulting.

When made into hay, the crop forms a very valuable standby to supplement the grass during the dry season and to maintain the milk supply, for the veldt grasses are then of low feeding value and very high fibre content with little protein, while the protein-rich lucerne tends to correct the effect of this poor, fibrous material.

It is probable that many people have been discouraged from converting the crop into hay on account of the difficulty of curing it without a great loss of leaf, which is, of course, the most valuable part of the plant. The strong sun bleaches it rapidly, and causes the leaves to fall.

For this reason, the majority of growers successfully making lucerne hay in this country dry the green material in a store, where it is shaded from the sun, and thus an excellent hay, secured with the minimum loss of leaf, is made. This is undoubtedly the best practice.

For those growers, however, who have not these facilities and yet are desirous of converting the material into hay, fairly good results can be obtained by stacking the material in the field, almost immediately after cutting, around tripods, building each into a large cock or pike, and allowing them to dry in the field in this manner. While the material on the outside of the pike will inevitably become bleached, and lose a good deal of leaf, yet that within will be cured gradually, and a fairly good sample will result. It is important that the pikes should not stand in the field too long; firstly, because the hay will then be overmade, and secondly, because they will tend to kill out the lucerne plants over which they are standing.

Varieties of Lucerne.

There are a large number of varieties suited to this country, and they may be divided broadly into two types:—

(*a*) Erect growing, relatively small stooling varieties.

(*b*) Lower growing, better stooling varieties.

Of the former class, Hairy Peruvian is the most outstanding. Its advantages lie in the facts that it is quick growing and therefore yields a crop sooner than other varieties, the seed is cheap and easily obtainable, and establishment in the early stages relatively simple. Its disadvantages lie in the facts chiefly that it does not stool very well, its crown always being relatively small, and it tends to grow upright without forming the bulk of material produced by some other varieties, and, further, some authorities claim that

it is not as drought resistant as compared with the other types commonly grown. From observations available in this country, however, there would not appear to be any marked difference in drought resistance as compared with the other types.

Of the lower growing, better seeding types, Provence, Grimm, Tagerim, Hunter River, Kansas Common, and Montana are probably the best known. Of these, Tagerim and Provence appear to be very promising in this country, although Tagerim is slow to get away when first planted. Grimm is an excellent variety, and very hardy, but the seed is usually expensive. Hunter River has given satisfactory results, and the seed is fairly reasonable in price.

Soils and Climate.

Probably, where the crop is grown without irrigation, a rainfall of about 35 inches annually approaches the optimum, although it can be grown on a rainfall as low as 25 inches, provided that distribution is uniform throughout the year. Where irrigation is possible, obviously this lower limit is capable of very great extension.

In the more humid districts of the Colony, with higher rainfall and higher temperatures (such as the Trans Nzoia), the crop is liable to suffer badly from attacks of leaf spots, which reduce yields very appreciably, and may even make the cultivation of the crop cease to be a commercial proposition. At present there are no varieties as yet tried in this country which have shown immunity or even resistance to these diseases.

As regards soil, it is important to consider the rooting habit of the plant, which is that of a deep tap-root. Roots have been traced in England in a porous gravel soil penetrating to a depth of 25 feet vertically downwards, and it is on this deep-rooting habit that the drought resistance of the plant depends. It is therefore important to grow the crop on a deep soil, where there is no pan close to the surface, so that the plant may be enabled to develop its normal rooting habit. As regards mineral ingredients, the plants like a soil well supplied in lime, although one often sees it on many "borderline" soils. Phosphate is essential for adequate root development, and also potash for the quick maturation of the plant. Lucerne will not grow on soils of the white alkali type, such as are present in certain parts of the country.

Cultivation and Preparation of the Seed Bed.

For the successful cultivation of lucerne, it is absolutely essential to have a clean seed-bed, for it is on this fact that the longevity of the crop will largely depend. If the land is foul with perennial weeds such as Kikuyu grass, it should be ploughed shallow, and the weeds pulled out with harrows, collected and burnt, this operation being repeated several times, if necessary, removing several crops of weeds. In bad cases a whole year must be devoted to the cleaning of the land, but provided that cleaning up and burning is carefully performed, most of the operations required for the destruction of perennial weeds can be performed during the dry season. Annual weeds should be germinated out by ploughing before rain and their immediate destruction with the harrows as soon as they germinate. This operation may also have to be repeated several times.

When the land has been thoroughly cleaned, a deep ploughing should be performed, and in cases in which a plough pan has been formed this should be broken through by subsoiling or extra deep ploughing. Subsoiling is preferable, since it does not expose raw, unweathered

soil on the surface. A subsoiler not generally being available on a farm, an implement can readily be improvised by removing the mould board from an ordinary single furrow plough, using the slade and share (the latter preferably of the chisel type) for the purpose. This implement should follow in the bottom of the furrow behind the ordinary plough and it will be found to break the pan quite satisfactorily.

In the preparation of the seed-bed for the crop it is essential to obtain it in a finely pulverized condition, but firm, for, like many other leguminous plants, such as the clovers, it will be noticed that a better take is obtained on the headlands, where the treading of the oxen in turning has consolidated the soil on the surface after ploughing. For this reason, use of the roller should be made freely, but it is always preferable to use a roller of the culti-packer or alternatively of the Cambridge type, for these implements, by leaving the land in small ridges or ribs, lessen panning on the surface in the event of heavy rain after planting. Panning under such conditions is apt to be more serious if a flat roll is used. Frequent harrowings and cultivations should be given to reduce the seed-bed to the necessary condition of fineness.

Preparation and Sowing of the Seed.

The ordinary sample of lucerne seed contains a fair percentage of hard seeds, i.e. seeds whose coats are very impervious to moisture, and which will therefore only germinate very late, producing weak plants, even if they germinate at all. The germination can be much improved by rubbing the seed between two pieces of coarse sandpaper for ten to fifteen minutes, prior to sowing.

Failure to obtain a stand on land which has not grown the crop before may be due to the absence of the necessary bacteria in the soil. This difficulty can, however, be overcome by scattering several loads per acre of soil from a field that has previously grown the crop on the field where it is proposed to grow it for the first time. This operation should be performed when the soil is damp, as if done when dry results may be very poor.

Alternatively, a special inoculum (stocks of which are available at the Kenya Farmers' Association) may be used, this being mixed with skim milk or water, according to directions, and this mixture incorporated with the seed immediately prior to sowing. It is absolutely essential, however, that this inoculum should be fresh, as in many cases the use of stale material has resulted in complete failures.

If there are members of the genera *Medicage* or *Melilotus* growing in the vicinity, and showing good nodule formation on their roots, it may be unnecessary to inoculate lucerne seed before sowing. As a rule, however, these genera are not sufficiently well represented in the local flora to obviate the necessity for artificial inoculation.

The growing lucerne should always be examined for nodule formation, since only when these are present will nitrification take place, and a good yield result. When performing the examination, the plants should be lifted very carefully, taking care not to break off the finer rootlets, where there are usually an abundance of nodules. Nodulation is most abundant when the plants are just coming into flower, but the nodules are always very small, and some people, expecting to find large structures, even the size of a pea, think that their lucerne has failed to nodulate when actually the nodules may be present in great abundance.

The seed rate for the crop should be 20 to 25 lb. per acre, the higher rate being used in the case of the lesser stooling varieties, such as Hairy Peruvian.

The use of a nurse crop in the establishment of the crop is to be deprecated, because it competes for the available moisture, and the resulting lucerne is usually weak and spindly.

Drilling is best performed in rows 6 to 8 inches apart, conveniently the width between the coulters of the wheat drill. The six-inch width is preferable. A certain amount of doubt exists as to the distance apart between the rows that yields the most satisfactory results, but the advocates of wider spacing (one foot, or even up to two feet) are usually dealing with land that has not been properly cleaned prior to planting, with the result that inter-cultivation at frequent intervals is necessary in the first or maiden year. Furthermore, this wider spacing entails waste of land. There is little doubt that the closer spacing of 6 to 8 inches, in addition to minimising wash on the field, will yield on the average heavier weights of green matter to the acre. However, for lucerne without irrigation, in areas in which the rainfall is not sufficient for heavy growth, wider spacing is necessary, up to 20 to 24 inches, with a lower rate of seeding (8 to 10 lb.) and cultivation should be practised. In all cases planting should be across the slope.

A wheat drill is very suitable for the actual sowing, but the seed should not be put in more than 1 inch deep, and frequently, particularly in the case of old drills where some coulters are more worn than others, it may not be found possible to sow at this depth. Cases are known where the presence of one new coulter on an old drill has caused the seed to be sown so much deeper from that coulter that it has never germinated. Where there is any doubt therefore about depth of sowing, drilling may be performed with the coulters raised, where the seed is, in effect, broadcasted in lines. Many authorities advocate broadcasting by hand or with a fiddle, but there is always the danger that if an unexpected dry spell follows planting, the seed may simply malt and die. Drilling 1 inch deep will ensure that the seed is in the neighbourhood of moisture. In either case, the seed should be covered after sowing, either with a roller or a brush (bush) harrow.

Treatment.

When lucerne is grown on dry land without irrigation it is inadvisable to cut in the maiden year, unless the crop shows a tendency to run to seed, for it is undesirable to allow it to seed in its maiden year. Where cutting is performed in this first year, the cut material should not be collected, but left on the ground as a mulch. Severe cutting during the early stages of growth prevents the plant from developing its root system properly and hence shortens its life appreciably. No after-cultivation of the crop should be necessary if a really clean seed-bed has been obtained in the first instance, and the seed sown either broadcast or in rows not more than 8 inches apart. Should, however, wider spacings have been adopted or the land become infested with wind-borne annual weed seeds subsequent to the preparation of the seed-bed, some inter-cultivation might be necessary. This work can be performed with the aid of a Planet Junior hoe fitted with chisel tines set very close together. In the second year of growth, moderation should be exercised in the cutting of the crop, and this should only be performed when the bulk of the field is coming into bloom. There is a great temptation during drought periods, when other food is scarce, to cut the crop too frequently, with the result that its life is very much shortened, and the expense of ploughing up and re-seeding will be incurred frequently. Probably during the second year it will be found that the crop will tend to close up across the rows, and also

a pan may be formed on the surface. Sooner or later, a root-bound condition appears, and it is at this stage that it is necessary to use a cultivator or disc-harrow to tear the roots and thoroughly aerate the soil. When a disc-harrow is used, run the discs straight and work along in the direction of the rows, and not across them. In this manner, little harm will be done to the stools, provided the operation is performed at infrequent intervals, at the most once annually, in the later years of the life of the crop, and thereby a tilth will be maintained on the land and weed growth will be checked. A stage will, however, be reached, depending on initial cleanliness of the land, fertility of the land, efficacy of after-cultural operations, and stand originally obtained, when weed growth and loss of plant have reduced yields very appreciably, and it therefore becomes advisable to plough the crop out, clean the land, and re-seed, or preferably grow alternative crops on the land for a few years to cash the fertility which has been stored up by the growing lucerne.

It is always important to remember that careful cutting of the crop without damaging the stools, controlled cutting, weeding, and cultural operations generally have a very important influence on the longevity of the crop.

Transplanting of Lucerne.

There is a fairly common conception that lucerne can be transplanted from a seed-bed into the field, either to fill up missing gaps, or to extend existing acreage. While it is quite possible to establish the plant in this manner, yet it is important to remember that it is virtually impossible to transplant successfully without breaking the root. It is usually bent when it is forced down into the soil, and will not grow straight again, but will fork in many directions, and will never penetrate very deeply; thus the plant loses much of its ability to withstand drought. The growth of such plants will therefore be slow, and yields will never be as high as if the crop had been sown directly in the field. For these reasons therefore the practice of transplanting is not to be recommended.

Manuring of Lucerne.

Where soils are lime-deficient, a dressing should be applied before planting and well worked into the soil by means of the cultivator, for lucerne is not only a crop which does best on a soil which is neutral in reaction, but it prefers an excess of lime to be present. While it is impossible to state definitely the amount of lime that should be applied, a dressing of two tons per acre is likely to yield satisfactory results. At the same time, many soils in Kenya, though slightly deficient in lime, appear able to grow the crop satisfactorily without any addition of this substance.

As the constant removal of green matter entails a considerable loss to the soil, artificial manuring is advisable to maintain yields throughout the life of the plant. Some authorities, in spite of the fact that the plant is leguminous, recommend the application of about 100 lb. per acre of sulphate of ammonia at time of planting to give the crop a start before nodule formation commences. This should not be repeated in latter years, for the application of nitrogenous manures to a leguminous plant when once it is established will discourage further nodule formation.

The use of phosphate is also to be recommended as a means of encouraging root development, and hence nodule formation. An application of the equivalent of 200 lb. of superphosphate in the year of planting, working into the soil before sowing the seed, is usually to be recommended, and subsequently further applications in alternate years during the

subsequent life of the crop. On potash-deficient soils, an application of 60 lb. per acre of sulphate of potash before planting yields satisfactory results.

Yields of Lucerne, and as a Grazing Crop.

While it is difficult to give any figure dogmatically for yields of lucerne, yet a dry land crop should yield, in a normal season, the equivalent of at least 3 tons of hay per acre. While some of the low-stooling varieties are said to withstand grazing successfully, this practice is not to be recommended as a general rule in this country, for damage to the crowns is always likely to result, and the life of the plant to be much shortened, and yields per acre will be much decreased. The ability to graze lucerne for many years in New Zealand without damaging the plant is due to the peculiar nature of the climate, the growing season being very prolonged, and conditions of rainfall, etc., very uniform.

Lucerne under Irrigation.

While this article has dealt mainly with the dry land crop, yet for those growers who are capable of irrigating very much higher yields can be obtained, and production secured almost throughout the year, and the longevity of the crop will be much greater.

The essential features in growing the crop successfully under irrigation are, firstly, to take care that the fields are laid out so that the distribution of water will be even and that it will not stand unduly long in certain patches, causing souring of the land and loss of plant. Good drainage is essential also to carry away surplus water.

Secondly, the crop must not be over-watered, the actual number of waterings depending on the porosity of the soil and rate of evaporation. The crop is best irrigated about ten days prior to cutting, so that when the material has been removed fresh growth may be made immediately. Some growers, however, prefer to irrigate after the crop has been removed, although a certain amount of plant may be lost in this way.

Over-irrigation will shorten the life of the plant very considerably, whereas, with controlled waterings, it should remain for a very long time, even up to periods of ten years.

Care should be taken to ensure that in the maiden year irrigation is done with care, and that a pan is not formed on the surface by the too frequent or too rapid application of water. Water should be withheld as long as possible in this maiden year, so that the plant may develop its root system properly. If the water table is too close to the surface, rooting will be very poor, and satisfactory yields in subsequent years will not be obtained.

It is stated that lucerne requires about 2½ to 3 acre feet of water per annum, or about 6 inches applied to each cutting.

Cotton Selection and Rotation of Supply of Improved Cotton Seed

By N. V. Rounce, *C.D.A., A.I.C.T.A. (Trin.),*
District Agricultural Officer, Tanganyika Territory.

Of the many practical ways of increasing the value and yields per acre of native-grown crops, plant selection is generally the last to be attempted. It must wait until the bulk of exportable produce justifies it or it depends on whether the food crop is a staple one. It is generally only a Government or a rich corporation that can afford to undertake selection work. The obvious economically controllable causes of low yields are: wrong or insufficient cultivation, wrong distances and times of planting, and sometimes insect damage. It is not unduly difficult to overcome most of these faults, when it then remains to improve the plant by selecting a strain or strains embodying the characters most suitable to the environmental conditions and to commercial requirements. There are very few crop plants which, when scrutinized carefully in the field, do not show a wide range of variability. Here lies the opportunity to attempt the increase of yields from two directions. There are the inherently unproductive plants which can be eliminated by propagating a strain which excludes them, and there are the plants with characters of positive value better than the average, which on selection and trial can be expected to yield above the average of the mass. Owing to the complexity of the genetic make-up of the cotton plant, it is less easy to attain that degree of closeness to the pure line which is possible in many other crop plants where self-fertilization is more the rule. With cotton improvement, it is therefore necessary to have a fresh supply of seed from a tested strain produced on rotation every year if possible. This rotation overcomes the possibility of the casual introduction of seed of different varieties or strains, as well as the possible crossing between uneradicated "rogues" of previous seed distributions, and the inevitable and not easily explained "running out" which so often takes place. In addition, unless a pure line has been attained, which is a difficult undertaking, the seed of any strain when redistributed over a period years, will segregate and deteriorate.

The methods of improvement by selection which may be adopted are two:—

(*a*) Mass selection, the seed of which may be put through the rotation as a preliminary trial.

(*b*) Single plant selection. This involves a selection of single plants which bear as near as possible a likeness to the perfect plant which is considered suitable for the area in question. The examination of their progeny in the field, with careful tests of lint qualities, and finally strain trials, may lead to the selection of a strain which is superior to the mixed type under cultivation in the area concerned.

In Tanganyika, there is undoubtedly considerable room for improvement in both vegetative type (which involves yield and maturity) and disease resistance, as well as quality of lint. At the same time, the cotton plant population is so heterozygous that there is considerable scope for selection, but at the same time this involves the risk of selecting a number of single plants which may be found to have exhibited hybrid vigour, and which are in any case difficult to "fix", and so have to be discarded.

Below is approximately the plan which could be followed in a selection and seed supply scheme, varying under different conditions, in respect of the yields obtained, and areas of isolation in which seed can be multiplied on a big scale:—

First Year.—Single plant selections. It is difficult to self these plants, as their qualities cannot be ascertained till after boll-maturity.

Second Year.—Progeny plots of each single plant selection which has passed a lint length test. Any progeny plot exihibiting variability between plant and plant is eliminated, but single plant selection may be taken if especially justified. A number of plants are selfed in each plot.

Third Year.—Strain trial of selfed seed of best progeny plots which pass lint, seed and ginning percentage tests, and are outstanding in field characters. The control plots are local seed.

Fourth Year.—Strain trial of superior strains of last year, together with new strains in first year of trial. Half to one acre multiplication plots planted in isolation.

Fifth Year.—Strain trial for third and last year. This allows a strain to show its response over probably three differing seasons and substantiates its claim to superiority. Twenty- to forty-acre multiplication plots planted in isolation.

Sixth Year.—300 to 600 acres of multiplication farm planted up with selected strain.

Seventh Year.—Resultant seed planted by natives in a gazetted area served by a ginnery or ginneries which buy only this cotton. All seed cotton purchased and ginned in strict isolation. This year of the rotation is an important one, and if there is no larger area which can be conveniently isolated for ginning, is the last but one in the rotation. The area must be large enough for more than sufficient seed to be produced in a bad season. If by any chance there is insufficient, then introduction of the strain must be abandoned for that year and seed from other ginneries used again. The seed of the sixth and seventh years can be put through a cotton marketing society, as in India, and distributed to registered seed-growers in the society. An alternative is to distribute the seed to registered peasant farmers around the multiplication farm.

Eighth Year.—Distributed to farmers over the whole area intended to be supplied.

This scheme can be so arranged to supply fresh improved seed every year to the planters, or every two or three years, according to the quality and purity of the seed produced. There is little doubt that even mass selection can give a distinct increase in yield, and it is indeed hard not to believe this when a study is made of single plant selection progeny plots and comparisons drawn. The elimination alone of the highly vegetative and leafy plants, of those which are extremely susceptible to disease, and those which are of poor vigour and bolling capacity, must help very considerably to increase yields by releasing the plant population of the heavy burden of practically unproductive plants. From the beginning, in selection work, the worker must have in his mind's eye a picture of the typical plant he requires, and he must know the characters for which he wants particularly to select, and keep them standard. There must be one or two especially important characters to aim at, and the rest should not go below a minimum valuation.

Notes on Turkish Tobacco

By C. J. McGREGOR, Dip. Agric.,
District Agricultural Officer, Tanganyika Territory.

Introduction.

The culture of Turkish tobacco is not difficult, but it requires specialized and practical study to be successful. It also requires constant supervision of labour, and meticulous attention to detail.

The cultivation of this crop commenced in the Southern Highlands of this Territory in 1927-28, and, whilst the production is not large, there appears to be a ready market for a limited amount in London and also locally.

Soils.

Turkish tobacco grows well on most of the soils of the Iringa District. It will produce economically on the soils derived from dolerite, schist, gneiss and granite, providing the nitrogen is limited. Too much nitrogen will give coarse leaf. The soils of the Miombo (Brachystegia) forest have so far been the most successful, where they are fertile and of a dark grey or reddish colour.

In selecting land, the fundamental rule that all tobacco, more so than almost any other crop, requires good drainage must not be overlooked. Terraced lower hillsides or sheltered tops of hills are best. A bottom soil is useless for the production of this type of tobacco. The subsoil should be friable and porous, and there must be no form of "hard pan", otherwise dark leaf will result. On the other hand, the type of subsoil should not be too porous, or light papery leaf will be produced. Leaching, too, will be excessive, and in dry seasons the crop will suffer from drought. A suitable soil is a sandy loam to loam with a loam subsoil, tending towards a clay loam lower down.

Climate.

There are specific climatic conditions required for the culture of Turkish tobacco. This type of tobacco is sun-cured, and there must therefore be no rainfall and only light dews during the curing season. The rains should cease about a month to six weeks after planting. Heavy rain at the time of maturity is detrimental to both quality and yield. Very high humidity will give dark, undesirable leaf.

The ideal conditions are light rains at planting time and onwards, followed by no rainfall, bright, sunny and warm weather, with light dew at night. The temperature should be in the vicinity of 70° to 85° F. in the shade, and should not fall too low at night. Frost at any time is fatal.

Seed-beds.

Turkish tobacco seed is sown first in seed-beds, and the plants are transplanted to the field when they are four to five inches high.

The seed-beds are prepared in the same manner as for Virginia type tobacco. This has been described in this Department's Pamphlet No. 11. For Turkish tobacco, however, the time of sowing and the rate of planting are different. One ounce of Turkish tobacco seed will yield sufficient plants for one-and-a-half acres. One ounce of seed should be sown on 120 square yards of seed-bed. Sowing is carried out at the end of November and the beginning of December in the Iringa District of this territory. Transplants are ready from the beginning of February to the middle of March. This is timed with the rains, which may cease at any time between the end of March and the middle of April.

Preparation of Land.

If virgin land is being used it should be cleared during the rainy season pre-

ceding that in which the crop is to be planted. No burning of bush or stumps should be carried out on the land itself, or uneven crops will result. In the Southern Highlands, if the clearing is carried out in December-January, the land can be ploughed in February and the tree roots removed. It can then be cross ploughed in March. At the beginning of the next rainy season it should be ploughed, and then just prior to planting it should be ploughed again and harrowed twice. If old land is being used it should be ploughed twice, once at the beginning of the rains and once just before planting is done.

Whatever land is to be used, it must be reduced to as fine a tilth as possible. Turkish tobacco is a quick-growing crop, and unless the soil is very thoroughly prepared the growth may be checked, which will have a serious effect on quality and yield. If the soil is of a clayey nature a disc-harrow can be used with great benefit.

Rotation.

No rotation trials have as yet been carried out with Turkish tobacco in this area. Experience, however, has shown that a Turkish tobacco crop following a leguminous crop is adversely affected in quality. The best practice seems to be simply to plant Turkish tobacco on the same land for two years, and then to rest the land for two years. Wheat or other small grain crop in the preceding year seems to have little effect on the Turkish tobacco crop if the soil is fertile.

Manuring.

Cattle manure or compost are not suitable for Turkish tobacco, as either will promote rank growth and give dark leaf too rich in nitrogenous bodies. The most suitable manure is old rotted sheep manure, applied at the rate of 3-5 tons per acre at the beginning of the rains or in the rainy season preceding that in which the tobacco is to be planted.

If artificial fertilizer is applied, the nitrogen should be supplied in an inorganic form. The organic forms darken the leaf. Blood-meal, in particular, is also too slow acting for the quick growing tobacco crop. The phosphorus supply seems to have a direct bearing on the potash. Potash supplied alone seems to have no effect on tobacco, and, as the potash supply is of the greatest importance, it should be supplied only with a quick-acting phosphatic fertilizer. The potash is best supplied in the form of the sulphate, and it may be advantageous to mix not more than 1 or 2 per cent of the muriate with it. Muriate of potash in quantity will damage the tobacco.

In the absence of exhaustive experiments these notes are essentially general. If the soil is fertile and the land is rested after each crop or every two crops, on the experiences up to the present in this area it would seem to be a suitable practice to use no artificial fertilizer. If the crop falls below 500 lb. per acre, however, it is thought that the formula, 8 per cent N, 20 per cent P_2O_5 and 10 per cent K_2O, might be tried, at the rate of 200 lb. per acre in drills, with advantage.

Planting.

Tobacco seeds number some 300,000 to an ounce, thus theoretically there should be approximately that number of plants for 1½ acres. Actually, there are much less. For 1½ acres about 40,000 plants are required, allowing for re-setting any that die. The balance, calculating on a 75 per cent germination, is allowed for unsuitable plants which are discarded. The seed-beds, after transplanting has been completed, should still contain a large number of plants. If this is the case, it will mean that only the best and strongest plants have been selected for pulling, and the crop has the best chance of being a good one. The importance of having an adequate supply of

plants, so that a selection of planting material can be made, cannot be sufficiently emphasized.

It is unnecessary to ridge the soil for Turkish tobacco. The usual method when planting is to use a measuring chain. In planting, the rows are made 2½ to 3 feet apart, and the plants are 8 inches to 1 foot apart in the row. Because of the method of harvesting, it is of the greatest economy to have an even crop, thus re-setting should not be done after a week or ten days. The time of planting in the Iringa District is the beginning of February to the middle of March.

The planting should be done either with the hands alone or with a *jembe*. The "dibble" method, i.e. using a pointed stick, is unsatisfactory, unless the natives are experienced planters. In many cases where the pointed stick has been used in this district, the natives have hung the plant in the hole by pressing the soil to the plant on the surface and leaving the roots in a hollow air space below. The soil should be pressed well to the roots, with the heart of the plant about half to one inch above the ground level. The roots must be in the natural position that they occupied in the seed-bed, and the taproot must not be twisted or bent in any way.

Cutworms are a cause of great loss in this district. The entomological leaflet on the subject of this insect pest should be closely followed. The greatest damage is done at planting time and for the first three weeks to a month after planting.

Cultivation.

Cultivation should be begun when the plants have become established in the field. The first cultivation should be shallow, and, if a horse cultivator is used, the set should be somewhat narrow, so that the young plants will not be disturbed or injured by the outward thrown soil. Straight-edged shares should be fitted for the first cultivation. After priming, cultivation should be deeper, and the arrowhead-shaped shares may be fitted to the outer arms of the cultivator. The later cultivations should be shallow, but deep enough to suppress the weeds and to reduce evaporation of moisture from the soil to a minimum.

Priming and Suckering.

Priming consists of removing the small leaves and any injured leaves at the base of the plant. These leaves are valueless and are discarded. Priming is done when the plants are 15 to 20 inches high. The stem of the plant should be clean at flowering time for about 5 inches from the ground. Leaves affected by mildew (usually the lower ones) should be removed, as mildew is inclined to spread upwards.

In some seasons, particularly wet ones, and with some varieties, suckers appear. These should be removed as soon as possible. Turkish tobacco must not be topped. The flower head is allowed to develop fully and to mature on the plant.

Harvesting.

Ripening.—The leaves of the Turkish tobacco plant ripen from the bottom upwards. Ripening is characterized by a yellow tinge appearing in the green colour of the leaf, from the tips first and then from the sides. The upper leaves, which are thicker than the lower ones, actually become flecked with yellow when they are ripe. It must be remembered that what is known as "ripening" is characterized by the colour of the leaf, but this change of colour is brought about largely by an accumulation of starches in the leaf, and these absorb some of the green colouring matter, so that the leaf yellows. In the curing, these starches are changed in character, but if they are not present the changes that must be brought about by curing will be incomplete. Thus, if green leaf is picked,

its composition is different from that of a ripe leaf, and the finished product will be different in character and flavour, which may make it unsaleable. It will thus be easily understood that it is of the utmost importance to pick at the right stage.

Method of Picking.—The leaves are picked in grades, as these grades ripen from the bottom upwards. The grades are determined by the position of the leaves on the plant. There are six grades in the tobacco in this area. The three bottom leaves (after priming) are called the "dips" or No. 1. These are thin, papery leaves, and fetch the lowest price. The next three leaves up the plant are the "first annas" or No. 2. These are poor, but are better than the dips. The "second annas" are next, and they are good quality. The No. 4's are the "third annas" and these are very good quality. The No. 5's, called "utz", are next, and the "alti", or No. 6, are the top leaves of marketable size. The number of leaves per grade differs in varieties. The leaves of each particular grade on any one plant are of the same size, texture, body, grain, etc. The leaves of each of the lower grades ripen together, but the upper grades ripen more or less by pairs of leaves.

From a practical standpoint, picking is arranged as the grade or part of a grade ripens. The field is arranged in sections according to the time of planting, and as each grade or part ripens it is picked. It will easily be appreciated that an even crop makes for ease of working and economy.

Picking is done in the morning, after the dew has evaporated from the leaves. It continues until sufficient leaf has been picked to deal with during the remainder of the day. This will usually mean picking from 7.30 to 10 or 11 a.m. The leaves are packed carefully in boxes all facing the same way, and are transported to a cool shed. The boxes are emptied on long tables, at which the workers are seated, and the leaves are sorted according to size and degree of ripeness.

Threading.—For threading, "needles" are required. The "needles" are straight strips of stiff iron strapping, about 1/16 inch thick, ¼ inch wide and 15 inches long. They each have an eye at one end, and a point at the other, and the sides and eyed ends are rounded. The leaf is pierced with the pointed end of the needle, through the mid-rib, about half an inch to an inch from the butt, and the leaf is pushed on to the "needle" as far as the eye. In this manner, the whole "needle" is packed with leaves, close together, all the leaves being of the same grade, size and degree of ripeness, and all facing the same way. The leaf is always pierced from the "front" of the leaf, i.e. from the upper side as it would be on the plant.

Stringing.—For stringing, sticks are prepared. These are six feet long, and about an inch thick. Bamboo is very suitable. To prepare a stick, a length of thin good quality cotton twine is tied to one end and left free at the other. The length of twine should be about six inches longer than the stick. To string the tobacco, the "needles" packed with leaves are first sorted, so that only leaves of the same size, grade and degree of ripeness will go on the same stick. The free end of the string on a stick is threaded through the eye of the "needle" and about a foot pulled through. The leaves on the "needle" are then pushed along on to the string, a dozen or so at a time, until all have been transferred. Four needles of leaves are usually threaded to one stick. When the string on the stick has been filled with leaves, the latter are lightly separated to allow air to pass between them, and the free end is pulled tight and tied to the end of the stick. Sagging of the string is prevented by

three short lengths of twine, which are passed under the string and over the stick and tied, leaving space for the butts of the leaves above the string. The stick of leaves is now labelled, showing the number of the picking, and the leaves are ready for curing. The beginner will find it useful to add the date of picking to the label.

Curing.

Curing is not merely drying the leaf. Certain physiological and chemical changes must take place in the leaves in order that tobacco be produced from the picked leaves. As mentioned in a paragraph above, the ripe leaves contain an accumulation of surplus food, largely in the form of starches. The curing process consists of gradually starving the leaf until this reserve supply of food is exhausted. The leaf then dies, and is almost cured. It is then dried out at a definite rate. There are a great number of types of tobacco leaf on the markets of the world, but this general principle of curing is largely the same for all types.

When the leaves have been strung on the sticks they are hung in the wilting room. This room is well built, tight walled and weatherproof. It should be dark inside, and should be situated on a site sheltered from dry winds. The sticks should be hung horizontally on suitably arranged tiers of poles. The tiers should be about 12 to 15 inches apart vertically, and, as the tobacco sticks are six feet long, the distance between tier poles horizontally should be 5 feet 10 inches. The spacing of the tobacco sticks in the barn is important. They should be as close together as possible, but not so close that leaves on different sticks touch. When the leaves have wilted, they take up less space, and the sticks of leaves should then be moved closer together, but still the leaves on adjacent sticks must not touch each other.

The temperature and humidity in the room must be under control, but no fire must be used, or the tobacco will become tainted. If the area is a suitable one for Turkish tobacco, there will be no difficulty in bringing this about by natural means. The relative humidity in the wilting room must be kept at 85 per cent. If it goes higher, the door is opened to allow the entry of dry air. The outside air will usually be dryer in areas suitable for curing Turkish tobacco. The usual trouble is that the relative humidity often drops below 85 per cent, and in that case water is sprayed on the walls and floor, due care being exercised not to wet the tobacco. The temperature should be kept at 70° to 80° F. Wet and dry bulb thermometers are useful, and if they are used the following table should be followed: —

Temperature in the barn. F.		*Depression of wet bulb.* F.
60	...	2.5
64	...	3.0
68	...	3.0
72	...	3.3
76	...	3.5
80	...	3.8

It has been found by practical experience that the optimum temperature in the barn is 70° F.

In from 3 to 6 days the leaf is wilted and yellowed, and it is then conveyed to the drying racks outside in the sun. The wilting and yellowing process requires judgment and skill, and here the label on the stick bearing the date of picking and threading is useful to the beginner. The length of the wilting and yellowing period for different types and grades can be noted on the ticket, and by judgment of the finished product he can see where mistakes are made.

The drying racks are an arrangement of two stretched wires, 5 feet 10 inches apart horizontally, and two feet from the ground. Eighteen inches above these

wires, and equidistant from them, is stretched another wire to support the covering which must enclose the tobacco at night. The drying racks run, in their lengths, from north to south, so that the sun can shine between the sticks all day. For the first two or three days, the tobacco is covered with hessian, and not exposed to the sun, or it will scorch. After this period it is exposed to the sun, and allowed to dry out completely; this takes 10 days to 3 weeks.

The tobacco must be covered at night to prevent wetting from dew. Canvas covers or double 10-oz. hessian is used. Any water in the form of dew or rain coming in direct contact with leaf will darken it and spot it, and may cause it to become mouldy.

Bulking.

When the leaves and midribs are completely dry, the tobacco is moved to the bulking room. Tobacco is hygroscopic, and it is thus moved in the early morning, when it has absorbed moisture from the damp early morning and night air, and is therefore not brittle as it would be later in the day. In the bulking room it is stacked on platforms, with an air space between the floor of the platform and the ground. Bulking must be carried out only when the leaf is soft and pliable after a night's heavy dew. The bulk or stack can be made as high as ten feet. No mouldy tobacco must be put in the stack or the mould will spread to healthy leaves. Every day, the edges of the stack must be lifted and the arm inserted to the centre of the stack at different levels to detect any heating, at the first signs of which the tobacco must be restacked, each stick of leaves being well shaken in the process. Restacking is advisable once a week. Bulking and restacking bring out the colour and aroma of the leaf.

Grading.

The first portion of the grading consists in dividing up the six pickings or grades. They should have been labelled so that this becomes a simple dividing up of the crop into six bulks. At the same time, any sticks containing green, discoloured or abnormal leaf are stacked by themselves for special attention. The second operation is "colour matching" and "sizing". This consists of dividing up the six grades into their various colours and sizes. There should not be more than two or three colours and two or three sizes in each picking, but the more even the crop and the more care taken at threading time, the less trouble and expense will there be in grading. If the sorting of the various leaves into classes of degree of ripeness and size was done before threading, the grading will be a quick, simple operation, as all leaves on one stick will be one grade, one colour and one size. If all leaves have been picked ripe, there will be practically no colour matching to do except where the soil is patchy. Thus, the operation of grading is largely what the planter himself makes it by the early treatment of his crop.

Baling.

For baling, the tobacco should contain 10 per cent of moisture. If it does, the midribs of the leaf will be dry, and the web of the leaf pliable. It should be possible, if the leaf is in the right condition, to bend the midribs through an angle of about 30° without breaking.

The baling is done by means of boxes and a press. The boxes are made with loose sides and bottoms which can be clamped into place by means of bolts and hasps and staples. The boxes have no tops. The inside measurements are 24 x 16 x 36 inches. The weight of the bales should be 80 to 90 lb. each. The press is a large screw fitted in a horizontally placed beam having two supporting vertical beams, each about 5 feet long, and bolted to a platform at the bottoms and to the horizontal beam at their upper

ends. The box is placed under the cross beam, and the screw works downwards on to a lid which fits into the mouth of the box.

A length of hessian, 6 feet long and 18 inches wide, is placed on the bottom of the box first. One end of this is flush with the end of the box and the other end passes out under the opposite end of the box. The strings of tobacco are cut to the length of the box, and the leaves are pressed out smooth, so that they lie flat, partly one on the other. They are then packed in the box with the butts to the sides. Three strings form a layer, and the box is filled with layers of leaf. The movable lid is then put on the top of the leaf, and is then pressed down with the screw. This operation is carried out three or four times, filling the box each time, until the weight of the pressed bale is 80 to 90 lb. and the height is 17 inches. The bale is kept under pressure overnight, and then the sides and ends of the baling box are removed. The loose end of the hessian is pulled over the bale, so that the one end and the top as well as the bottom only are covered. This leaves the two sides and the one remaining end open. The hessian is sown tightly in this position in a criss-cross fashion with thick white cotton cord to act as laces across the open sides and end. The bale then appears as the buyer sees it. For despatch, it is again sown in double hessian to completely cover it, over the laces and hessian in which it is baled. On the market this outer covering is removed by the selling agent.

Fermentation.

This process follows the baling, and is usually carried out in bulk by the manufacturer. If the tobacco is sold locally the grower can ship as soon as convenient after baling. For export, it may be necessary to ferment the bales of tobacco prior to despatch.

Conclusion.

There is no market for inferior Turkish leaf. The grower is therefore urged to study the crop and to devote that attention to detail which the growing and curing of a successful crop of Turkish tobacco demands. The notes set forth above are a short description of the principles and the practical methods of cultivating this crop. The essential details will easily be grasped after some practical experience. The new grower is therefore advised to start with a small acreage, increasing as he becomes more proficient in the carrying out of the various operations and in the special organization of the native labour.

Notes on Cotton Breeding in Uganda

By G. W. NYE, *B.Sc.* (*Lond.*), *Dip. Agric.* (*Wye*),
Senior Botanist, Uganda.

I.—HISTORICAL.

It will probably be of interest to give a short summary of the history of cotton in Uganda before proceeding with a general description of the methods we have adopted in this country for the improvement of the existing crop.

Cotton was first reported by Speke and Grant in 1862, while in 1872 Samuel Baker introduced "Gallini" cotton into the area round Masindi. Emin Pasha, writing in 1880, reported that he had found cotton being cultivated on a small scale in Bunyoro, Gulu and the West Nile, and that a local weaving industry existed. In 1910, Lamb reported having found specimens of *Gossypium obtusifolium* var. *africana* and also *G. Brasiliense* on the northern shores of Lake Kwania, but at the present time the only "wild" cotton found consists of an occasional group of plants of *G. Brasiliense* in Buganda and in Busoga. In the latter district, where the local name is *Bufumese*, quite a skilled local spinning industry exists in a very small way, and caps and belts are still made from this cotton.

The commercial possibilities of cotton were first recognized by Mr. Borup, who introduced a number of varieties of Upland cotton for trial in Buganda. This trial was successful, and as a result the Government introduced a quantity of Egyptian cotton seed in 1903. This failed, but a further series of introductions of Uplands by Mr. Borup in the same year was successful, and the result was the importation of a ton of the Upland variety "Black Rattler" in 1905. In 1907, a further ton of American Upland seed (variety unknown) was obtained, and distributed in Busoga and Buganda. The result of the numerous types which were imported and distributed in rather a haphazard fashion in these early days is seen in the amazing mixture of types which constitutes the Buganda crop at the present time. 1911-12 saw the opening of the first cotton experimental station at Kadunguru in Teso District, and from that time until 1930 all work on cotton selection was concentrated in this area. The variety "Allen" was distributed all over the Eastern Province in 1913-14, but this was replaced by a selection from the variety "Sunflower" made at Kadunguru in 1916. Buganda was also planted with this selection, but in this area no special precautions were taken to prevent mixing of the seed with the heterogeneous collection which already existed. In 1915-16 the first Nyasaland Upland cotton was imported, and this type has formed the basis of the Eastern Province crop since that time. A very successful selection from this type—N. 17, made by Mr. Harper at Serere, which had been opened up in 1922 to replace Kadunguru—was eventually distributed all over the Eastern Province. It has since been replaced by S.G. 29 (another Nyasaland derivative selected at Serere) in Teso, Bugwere, Budama, and Bugishu Districts.

The following summarizes the distribution in the Protectorate of the various types at present in general cultivation:—

Buganda and Western Province.—A very unstable and heterogeneous collection of varieties and types, with "Black Rattler" and "Sunflower" forming the basis. No new seed has been introduced into these Provinces since "Sunflower" in 1916.

Northern Province.—With the exception of Lango, this is planted up with S.G. 29; Lango is still under N. 17.

Eastern Province.—Busoga District has N. 17, the remainder S.G. 29.

II.—PRESENT PROBLEMS.

For cotton breeding purposes, the Protectorate is divided into two areas, each of which is served by an Experiment Station.

The western area comprises all that area west of the Nile, and for the most part consists of the Lake Basin and elephant grass areas. This western area is served by the Bukalasa Experiment Station, situated in Mengo District of Buganda. This station was opened up in 1922 for general experimental purposes, but it was not until 1930, when the Senior Botanist was transferred there from Serere, that any cotton-breeding work was carried on in this area.

Serere serves the eastern area, which comprises for the most part the short grass drier country east of the Nile. It was opened up in 1922, and cotton selection has been going on since 1923. At the present time a Botanist is stationed there to carry on the cotton-breeding work for that area.

The main problems which confront us in Uganda may be summarized as follows: In the western area, the most immediate problem is the stabilization of the crop to produce a uniform product, and at the same time to improve the staple length, which has deteriorated in recent years as a direct result of the mixture which comprises the crop. The quality of Uganda cotton has been the means of building up the present industry, as it is of the long-stapled American type, of which there is a comparative shortage in the world, and for which there is a very definite demand in India, Japan and elsewhere. Any falling off of this quality may seriously affect our present market, and we therefore have to take great care to try to maintain the crop at the required standard. The yield question in most parts of the western area is not so pressing, and with improved spacing there is no reason at all why average yields of 600 to 700 lb. to the acre should not be obtained.

In the eastern area, the problem is rather the reverse: The Nyasaland types are fairly satisfactory as regards quality, but they leave much to be desired from the point of view of yield, especially in the drier areas of low fertility in Teso and Bugwere. We require the same staple (1-3/16th inch) in this area as in the western area, but it is more difficult to obtain, as the more adverse soil and climate conditions make for a loss of between one to two millimetres in staple length. For example, the same cotton grown at Bukalasa and Serere will as a rule be from one to two millimetres longer in the former station than at the latter.

In addition to these major problems, we are faced with several other factors of prime importance, such as resistance to "Blackarm", a disease which thrives on most of the Nyasaland types, and which can practically annihilate the crop, given favourable climatic conditions for its spread. Fortunately, resistance to this disease appears to be a genetic character, and both at Serere and at Bukalasa highly resistant strains have been isolated. Another disease which is now coming to the fore is the Fusarium wilt disease, which is spreading steadily in Buganda. Work on resistance has already been taken in hand. Jassids have to be considered, especially in the Eastern Province, where serious damage can be done. For instance, the promising variety S.G. 23.8 was tested in this area, and found to suffer badly from this pest, and as a result had to be discarded. In Buganda, how-

ever, conditions do not appear to favour serious attacks of Jassid, and although S.G. 23.8 has been grown in various centres since 1930 no Jassid damage has been observed. The habit of growth is an important point, especially as plants liable to lodge produce a much higher proportion of stained and muddy cotton than erect types. Erect trees also make for easier picking, and we have already obtained a number of types with very erect stormproof habits, more especially from the U.4.4.2. group at Serere.

Now that Pink Bollworm is general, in Buganda at any rate, work will be necessary to produce early maturing varieties, as these would give a shorter season for the pest to multiply in.

III.—Methods.

The following gives a brief account of the methods at present in use to tackle the problems outlined above:

Improvement in plants can be obtained by three methods: (1) Selection, (2) New introductions, and (3) Cross-breeding. All three of these are being tried in Uganda, but as the most rapid results are likely to be obtained from (1) and (2) most of the cotton-breeding work is concentrated on them. Cross-breeding is rather long-range work, but it is not being neglected, and we have great hopes of combining the quality of the Nyasaland types with the yielding powers of the U.4.4.2 types.

Selection & General Methods of Testing.

Original selections are originally made in the field, either from new introductions and other crops growing on the experiment stations, or in native plots in the districts. By far the most hopeful source of material lies in the mixed state of the Buganda crop, and an increasing number of selections are made annually from this nest egg. Any outstanding plants may be selected, although it is unusual to select outside plants, as these are generally benefiting from the lack of competition. The lint from these selected plants is examined in the laboratory, and any falling short of our standards are discarded, unless some outstanding character, such as complete resistance to disease, very high yield, etc., warrants their retention for possible crossing purposes. In the following season, these selections are included in the first stage in the breeding plot, known as the New Selection Series. A row of twenty plants is grown of each selection, and observations are made at weekly intervals from the time of germination until the plants are uprooted. In the early stages, observations on Primary Blackarm are important, and a number of selections may be discarded on this account. Later on, resistance or susceptibility to Jassids and Lygus is investigated, and as the plants develop notes are made on habit: the Nyasaland types are very prone to lodging, and S.G. 23.8 is the most erect selection from this type that we have yet obtained. More promising results have been obtained in U.4.4.2 derivatives and from local Buganda selections.

The Nyasaland types also depend to a large extent for their yield on the production of basal monopodia, and any damage to these by Blackarm in the early stages results in a considerable loss of crop. Selection for types depending to a less extent on monopodia for the crop is carried on.

As soon as flowering commences, all the flowers are self-fertilized, in order to prevent cross-pollination with neighbouring types, which occurs in the field to the extent of 14 to 20 per cent. The method of selfing used is to tie the tip of unopened flowers with sisal fibre early in the morning of the day on which the flowers are due to open. The work is done by a team of children, and anything up to 200,000 flowers are selfed annually at each station. A piece of coloured wool

is tied round the stalk of each tied boll, so that any flowers which escape selfing can be easily recognized at harvest.

Notes on maturity are made, and pickings are done at regular weekly intervals. At each pick the bolls from each plant are cut off and placed in a coloured envelope, and any unselfed bolls are picked into yellow envelopes, it being a matter of laboratory routine that any cotton in yellow envelopes is thrown away after examination. The following records are made on the produce of each pick: Total number of bolls, total number of loculi (boll divisions), and total number of diseased loculi. The cotton is then kept in *americani* bags, one for each plant, and at the end of the season it is weighed, ginned, and the ginning percentage worked out. The ginning percentage is an important character, as although two varieties may give identical yields of seed cotton there may be a difference of five per cent in ginning out-turn, which makes a great difference in the amount of lint produced.

Ten seeds each from a separate boll are retained for lint length estimation, which is done by pulling tufts from seed combed out on black velvet covered boards; the tuft is placed on black velvet, and its length estimated by means of a glass ruler superimposed on the tuft. At the end of the season the results are carefully analysed, re-selections made, and in satisfactory cases the new selections are promoted to the next stage: Pedigree Lines. It may be mentioned that uniformity of lint characters is all-important, and as a rule the new selections split up into diverse types in this respect as well as others. In these cases rigorous re-selection is done, and no strain is put into the Pedigree Lines until it attains what may be termed "economic purity".

Pedigree Lines.

These consist of promotions from the New Selection Series, and two to four rows of 25 plants each are planted, according to the amount of seed available. Between each pedigree line are planted two rows of the cotton which happens to be in general distribution at the time. These local rows are used for eye comparisons with the new strains under test. Similar observations are made on the pedigree lines as for the new selections, but tests are more rigorously applied, and, in addition, flower counts are made to obtain the rates of boll shedding. Considerable reduction in rates of boll shedding can be obtained by selection. For instance, the variety S.G.23.8, which has been referred to above, gives a boll shedding percentage of approximately 45 per cent as compared with 50 to 65 per cent in local and S.G.29. This year re-selections from S.G.23.8 have shown a further reduction still, and three pedigree lines have given shedding percentages of only 35 per cent and under. In the pedigree stage more attention is paid to lint characters, and use is made of purity targets to test uniformity; the ginning out-turn being the other character used. When possible, samples of lint are tested in the Balls cotton sorter, and are submitted to local lint buyers for their opinions. Pedigree lines passing the various tests satisfactorily are then bulked up for variety trials and other tests.

Variety Testing.

As no true yield tests can be applied in the pedigree lines, it is desirable to obtain some indication of the yielding powers of a new strain at as early a stage as possible. For this purpose, the first yield trial takes the form of a miniature variety trial, in which a single row is a plot. Between eight and ten of the pedigree lines may be included in this trial, as well as local, and each variety row is repeated eight times at random.

The next stage of variety testing is the big variety trial at the experiment station and it usually consists of eight varieties,

including local, in a latin square or random blocks. Observations capable of mathematical and other interpretations are made on germination, Blackarm infection, Jassids and Lygus, lodging, total yield of seed cotton, total yield of lint, percentage of low grade cotton, and so on. At the same time sufficient lint is available for spinning tests, and 7 to 10 lb. samples are sent annually to England and India for this purpose. The assistance given by the Shirley Institute in Manchester and by the Technological Laboratory of the Indian Central Cotton Committee in carrying out these tests, and giving full reports on the results, is invaluable. The spinning test is the final criterion of a new variety, and if it fails in this respect it is rejected.

As is easily understood, neither Bukalasa nor Serere are typical of the whole areas which they serve from a soil and climatic standpoint, and extended tests of new varieties are necessary before any one can be selected to replace that already in general cultivation. For this purpose, a number of centres representative of definite soil and climatic types have been selected throughout the Protectorate—eleven in the eastern area and nine in the western. At each centre a variety trial is conducted annually, consisting usually of three new varieties, together with the control. Mycological, entomological and botanical observations are made whenever possible; distance rendering more than two annual visits rather out of the question. At each centre a native observer is stationed, who is in charge of the trial, and who takes rainfall and other meteorological observations. These observers are now being trained to make simple observations for Blackarm, Jassid and Lygus attacks. The results from these district trials are very valuable, as they supply information as to the behaviour of new varieties under diverse soil and climatic conditions. Naturally, the results of a single year cannot be taken as being correct, and several years of tests in these district trials are necessary before a new variety can be confidently put into general distribution.

First Stages in Multiplication.

As the tests of new varieties proceed, they are bulked up, so that in the event of one being found suitable for distribution a supply of seed is available. The first stage after the pedigree lines is an isolated quarter-acre plot, which supplies sufficient seed for the main variety trial and for the next stage of increase, and also sufficient lint for the first spinning test.

The second stage is an isolated plot of one-and-a-half to three acres, and from this seed is obtained for inclusion in all the district trials and for stage three.

Stage three consists of 18 acres at Bukalasa and 40 acres at Serere, and this is also isolated, a minimum of 200 yards from any other cotton being taken for the purpose of isolation. This stage gives sufficient lint for several bales, and a large scale commercial test is possible. The seed is used for the seed farm area in the next year, after which the variety is put into limited distribution in segregated areas.

IV.—PRESENT POSITION.

In conclusion, it may be of interest to record the details of some of the most promising strains we have selected out.

Some of the most promising in the Eastern Province are derivatives from U.4.4.2, the original seed of which was kindly supplied by Mr. Parnell from South Africa. Unfortunately, the general lint character of most of these selections is below our standard, but in every other respect they represent an enormous improvement over the Nyasaland type. There is no doubt whatsoever that if the question of maintaining our quality was not so essential we could obtain an increase in yield of at least 50 per cent

to-morrow in the Eastern Province. Work is proceeding on selecting for quality amongst these U.4.4.2. derivatives, and two strains, S.P. 56 and S.P. 86, are very promising in this respect, and appear to have lint of a quality very little below that of S.G. 29. In addition, these strains are highly resistant to Blackarm and Jassid, and also have very excellent habits of growth. They are also early maturing. Another great advantage of these strains is their high ginning percentage of 35 per cent and over, as compared with 30 to 31 per cent of Nyasaland types.

In Buganda, we have S.G. 23.8, referred to above, which is by far and away the best spinning cotton we have in the country. Its staple is on the short side, but this does not appear to affect its spinning characters. It is rather susceptible to Blackarm; rather more so than local Buganda in this respect. Its yield of seed cotton is about the same as local, but its ginning out-turn is higher, and consequently so is its yield of lint.

Another very promising strain at Bukalasa is B.P. 50, which is at present only in the early stages of increase. It appears to have most excellent quality lint, showing a great improvement over local Buganda, while its yield is practically the same; additionally, it is earlier maturing than local, and has a more erect habit of growth. Its uniformity is definitely better than that of local in every respect. Other strains are promising—B.P. 52 on account of earliness, combined with good quality lint; B. 31 for high resistance to Blackarm; and several new pedigree lines derived from S.G. 23.8, which have very low boll-shedding rates indeed, combined with good yields.

Tea Cultivation in the Southern Highlands of Tanganyika

By R. M. DAVIES, *B.Sc., District Agricultural Officer, Tanganyika.*

Introduction.

Tea is being established on a commercial scale in two separate areas of the Iringa Province in the Southern Highlands, namely, in the Mufindi and Rungwe Districts. The possibilities of tea-growing in the latter area had evidently been considered in German times, for seed was introduced by one of the missions over twenty years ago. The plants were allowed to grow unchecked, and are still there, but no attempt was made at development.

It was not until 1924, when Major Wells began planting tea on a small scale with seed obtained from the old trees of the mission, that attention was again focussed on the possibilities of a tea industry in this region. Later, in 1928, when the forest belt overlooking the Mufindi Escarpment was thrown open to settlement, a few of the early and enterprising planters set about growing tea. None of the early pioneers, and few of those who are in the field at present, have had previous experience of tea-planting elsewhere.

For the assistance and development of this industry Government has given free grants of seed, and since 1930 an officer of the Agricultural Department with some experience of tea cultivation has been stationed in the area in an advisory capacity. In 1932, Government were able to secure the services of Dr. Mann, who not only visited the areas at present being concentrated upon, but also other parts which might prove to be possible extensions of tea cultivation. As a result of his investigations, there was published his comprehensive report on "Tea Cultivation in the Tanganyika Territory and its Development."

Before dealing with the subject of growing tea in the Southern Highlands, it should be mentioned that it is an expensive crop to establish, and that so far development has been in the hands of planters with very limited financial resources, dependent upon central manufacturing facilities, from which it is clear that expansion could only be and has been very gradual. The total acreage under tea in the two districts is now approximately 1,100 acres, of which 600 acres are in the Mufindi District and 500 acres in the Rungwe District; of this total, about 325 acres are in bearing. All told, there are about thirty planters engaged in the industry. Two factories, one in each area, are in operation, and another is in course of erection.

Whilst the cultivation of tea follows certain general principles in all the countries where it is grown, the procedure must be varied according to the special climatic and other conditions. Not only are there considerable variations in the conditions as between the two districts but there are also features as regards some of the conditions which are quite unlike those prevailing in any of the other tea-producing countries of the world. It is necessary to emphasize this point, because it is clear that, until experiments can be conducted over a period of years, and until detailed records are available, the correct procedure to be adopted cannot be confidently laid down. Owing therefore to the very recent introduction of tea to these areas, and for other reasons as well, there is very little that can yet be said on some important points with any degree of certainty. As an instance of this, it is still not known whether pruning should be done annually or at longer intervals.

General Features of the Tea Districts.

Mufindi is approximately 8½ degrees south latitude, and lies at an average elevation of 6,150 feet, on the edge of an escarpment. The forest belt being opened to tea stretches for 30 miles, and is 5 miles wide. It is estimated that of this about 12,000 acres are really suited to growing tea. The distance from the centre to the railway at Dodoma is 263 miles, the area being well served now by a good all-weather road. The rainfall averages about 70 inches, the maximum fall being along the summit. During the cold weather, after the rains have ceased, heavy dews with morning and evening mists are characteristic. The forest soil is a loam with a high percentage of organic matter. It has a very open texture, with a large amount of coarse sand in its composition. Below, the subsoil is of a more clayey nature, but still very free draining; it has been formed *in situ* from a granite. Although the country is broken, the slopes are not usually very steep.

The Rungwe District is 200 miles by road from Mufindi to the south-west, where the area under tea is mainly at an elevation of 4,000 feet in undulating country facing Lake Nyasa. The district is linked to the central railway by an all-weather road over a distance of 450 miles, though an alternative outlet is via Lake Nyasa, thence by rail to the Port of Beira. The rainfall approximates 100 inches, and mists are common in the cool months. The soil is of volcanic origin, and open in texture. Since both these areas lie to the south of latitude 4° S., there is one rainy season instead of two. The rains occur from December to the end of May. The coolest months are June, July and August; the warmest is November.

Planting.

In preparing the land for planting, where forest occurs, as in Mufindi, this is felled and all stumps and roots removed, after which the clearing is either dug over or forked. Care in the selection of site has to be taken to avoid slopes exposed to cold winds, and to leave adequate wind belts. In the Rungwe District the problem in preparation is to rid the land of two pernicious species of grasses with creeping underground stems. Although the general lie of the land is hilly, the slopes are not usually steep. As yet, no elaborate systems of contour drains have been laid out.

Good *jat* tea seed has been available from local seed bearers in the Rungwe District, in addition to which importations of good seed have been made from India. Fortunately, no areas exist which have been planted up with inferior seed, in spite of the high cost of good tea seed.

The planting distance first adopted was 5 ft. x 5ft., but this has been changed either to 4 ft. x 4 ft. or to close hedge planting. Contour planting is now the rule. Plants from seed planted at stake during the first rains, and carefully shaded through the first dry season, thrive better on the whole than transplants. If seed can be obtained at a suitable time to raise small three months' old seedlings, to put out at the beginning of the rains, these do quite well. Year-old and even two-year-old stumps receive a number of checks, firstly due to the transplanting, then to the cold weather after the rains before they have properly established themselves, and finally from the dry weather which follows, so that little or no growth is made for a year after being put out in the field. These conditions are aggravated in the Mufindi area because the surface soil contains a large percentage of coarse sand.

Soil Preservation.

It has been said above that no elaborate drainage systems have been laid out when clearings have been opened. When

it is understood that the majority of individual planters have not much more than 50 acres under tea, it will be realized that in such early beginnings there is available plenty of choice as regards site from a holding of, say, 500 acres. The result is that the gentlest slopes have generally been chosen. Where the slope is less favourable, terraces and contour hedges, together with catch-pits, are usually being adopted. In some instances, the tea bushes are planted as a hedge on the contour.

The use of hedge plants and quick growing annual crops is general, as a source of green material to incorporate in the soil as well as to prevent soil wash. In addition, weeds in the early years are very prolific, and these are heaped along the contour, so that ultimately terraces are formed.

Of the bush plants used for the purpose, a species of Tephrosia, indigenous to the locality, is the most promising. It appears to thrive well at all elevations, produces an abundance of leafage, and a root system which tends to be deep. A popular plant in the Mufindi area, intersown with the above, is a species of Lupin imported from Germany. Two Indigoferas, and several other selected wild species of Leguminosæ, are left to grow wherever they may occur, and seed is even collected and brought in, and scattered through the clearings; by this means they are given a practical and extended trial.

As yet, no suitable perennial ground cover crop has been found. Two species of Desmodium, which are indigenous, are being experimented with in Mufindi, and so far as their manner of growth is concerned they appear to be very satisfactory. One of the problems, however, is to find a soil cover which can be grown with the tea throughout the dry spell without detriment to the latter. Use has been made of Serradella as a quick growing green manure crop, but where it had been allowed to remain after the rains were over there was evidence for believing that the young tea was adversely affected.

The growth of trees among the tea is general throughout both districts. The trees most commonly used at the lower elevations are various species of Albizzia. In Mufindi, Grevillea has been generally planted because of the fact that it flourished well there, and because it was difficult to find a leguminous tree suited to the conditions. *Acacia decurrens* can be grown with success, but some apprehension has been felt as to what its effect would be when interplanted among young tea.

Pruning.

The system of treatment of the young plant and subsequent pruning which is being followed is one advocated by Dr. Mann. The first pruning is done at a height of 4 inches, when the plant is less than a year old. After this, the next cut is made at 14 inches from the ground, and is carried out when the bush has made suitable vigorous growing young wood. The measure for the third and subsequent prunings, until it is necessary to come down again, is two inches above the previous cut. A consideration which is of much practical importance in respect of this method of pruning is that it is simple to follow. Neither the pruning cycle nor the approximate date when pruning should be undertaken has been worked out for either of the two districts. Owing to the pronounced dry season, which checks the growth of the bush, thereby causing the wood to harden prematurely, and to the strain on bushes carrying full leafage at this time an annual pruning is favoured.

Plucking.

The distribution of rainfall and the temperature do not permit of a regular supply of flush throughout the year. The

total crop has to be secured over a limited period. In these respects, there is some similarity to the conditions prevailing in North-East India, with this important difference, however, that from the very onset of the rains the temperature here is gradually falling and the production of crop slowed down earlier than would happen were the temperature to remain more favourable. Bearing in mind the consideration of an annual pruning, the problem is complicated, in that it has been found, on the lower elevation tea at all events, that September, virtually three months after the rains have ceased, can produce more leaf than any other month, and tea of good quality. Since an appreciable area of tea is only now coming into bearing, there is no means of judging what system of plucking should be adopted. It is clear that the method will have to take account of obtaining a maximum yield over a few months.

Manuring.

A simple experiment was laid down in 1932 on an estate in the Rungwe District to try and find out to which of the manurial constituents the tea responded most under local conditions. Although the period from the time of laying down the experiment is short, an opinion on the results to date can be expressed. The effectiveness of a complete artificial mixture is very noticeable. Nitrogen seems to be the ingredient most required for producing good yield and a vigorous healthy bush. Sulphate of ammonia is perhaps the most useful in this respect, particularly as the sulphur it contains is necessary for the cure of "tea yellows". There are indications that an addition of potash to this soil is more necessary than is usually the case elsewhere. A similar experiment for the same purpose has recently been laid down in young tea at Mufindi. Information is also being sought as to the cause there of a seasonal yellowing which is not "tea yellows".

Apart from the consideration of introducing highly concentrated inorganic artificial manures, which are costly on account of the high freight, there are local sources of organic manures. Cattle manure, giving an analysis 0.35 per cent of nitrogen, can be bought from the natives of the Rungwe District, but cannot be readily obtained in the other district. Bat guano, mainly phosphatic in composition, is within reasonable distance, and further afield supplies of organic meal from a meat factory are available. Planters are fully aware of the necessity of providing as much as possible of the necessary plant food on the spot; the manufacture of compost has begun, and the production of an oilcake is under consideration.

Pests and Diseases.

Before much tea had been planted up in the Rungwe District, it was fortunate that Dr. Storey, of the Amani Research Station, and Mr. Leach, Mycologist, of the Nyasaland Department of Agriculture, had investigated in Nyasaland the "tea yellows" disease, for which they found a simple and inexpensive cure. So generally prevalent is "tea yellows" in the district that the application of sulphur in some form or other must be considered as an indispensable part of tea cultivation there. When experiments were being carried out on a small block of tea to confirm locally the findings of Storey and Leach in Nyasaland, it was soon necessary to abandon the exclusion of sulphur from the control rows on account of the number of plants which were being lost.

Up to the present, the occurrence of root disease on the tea has been insignificant, which is to be accounted for by the fact that careful preparation of the land by removing all stumps and roots before planting has been the practice. Exotic trees interplanted have not

reached the stage when they could become a menace.

The tea "mosquito" (*Helopeltis*) has caused some trouble in the Rungwe District, particularly to young plants. The serious nature of it in this direction is the damage which can be caused to the young wood, which in the ordinary course of events would become the permanent framework of the mature bush. This type of damage has been clearly demonstrated by Mr. Smee, Entomologist, of the Nyasaland Department of Agriculture.

Manufacture.

Unless there is the necessary equipment for carefully controlling the various steps in the course of the manufacture of the leaf, the final result is bound to be uncertain and erratic. The lack of up-to-date equipment was a difficulty with which the original factory operating in the Rungwe District had to contend. Despite these shortcomings, parcels of tea have been produced from which it is apparent that, with careful plucking and manufacture, a good flavoury tea is to be expected during certain months of the year. Improvements are being made, and a second small factory with modern equipment is in course of erection.

In the Mufindi District there is a well appointed factory, fitted with an ingenious system for artificial withering, as well as all the necessary machinery for making the best tea. A trial run of the factory last season demonstrated the necessity for some slight alterations to some of the machinery and withering arrangements, and it is now settling down to a full season's work, after which it will be possible to judge of the quality of tea this district is capable of producing. A considerable number of planters with limited means and quite small acreages depend upon these factories for the manufacture of their leaf.

Kiln Drying of Copra

By C. B. GARNETT, *M. A., District Agricultural Officer, Tanganyika Territory.*

It can safely be stated that fully 60 per cent of the copra produced in Tanganyika, other than that manufactured on the large estates, is of the very poorest quality, and that only a small proportion of the balance can be classed as even reasonably good.

There would appear to be two main causes contributing to this unsatisfactory state of affairs, viz: (1) The prevalence of the theft of nuts—mature and immature nuts being stolen indiscriminately—and (2) The careless and slovenly method under which the copra is usually prepared. It was in an endeavour to combat the second of these causes that the writer paid a visit to Zanzibar during 1932 for the purpose of gaining some knowledge of the construction and utilization of the very simple types of drying kilns there in use.

Stated briefly, the kilns found to be in use were of two types, the main difference being that one is constructed mainly below ground level whilst the other is entirely above ground.

Subsequently, two experimental kilns were erected in Dar es Salaam. The below ground type was an immediate failure, owing to the loose sandy nature of the soil in the locality. The walls quickly crumbled and fell away, and it was decided that the increased cost of reinforcing the walls, either by sheet iron or mud bricks, would not outweigh any advantages this type of kiln might possess over the above ground type. A second kiln of this latter type was therefore erected, and the two kilns have been in use for experimental purposes for the last two years.

The floor space of each kiln measures 14 ft. by 25 ft. Second-hand corrugated iron is employed in constructing the walls of the firebox, which are 3 ft. in height, and the floor on which the copra is to be placed (also constructed of corrugated iron) is supported on old rails. The drying surface is covered with sand, and it is by manipulating the depth of sand used that the heat is regulated. Finally, the midribs of coco-nut leaves are placed on top of the sand, and on these the copra is placed, the wooden ribs serving to make the nuts easy to handle and keeping them clean. There are doors on three sides of the kiln, by means of which the fire is fed and the draught regulated. The chimney, constructed of old cement or tar drums, is on the fourth side of the kiln, and connected thereto by a short passage some 3 ft. in length. If a pair of kilns is constructed, the chimney stands between and serves both, and it is believed that one chimney would also serve a block of four kilns if desired. The construction is completed by a roof built of matted coco-nut leaves or other material of common native usage.

It is difficult to say what the cost of a simple kiln of this type would normally be, but it is certain that it should not exceed a sum of £30. Actually, the two kilns in use in Dar es Salaam cost only Sh. 700 for the two, but this figure should be taken as nothing but a guide, as many of the second-hand materials used were obtained from other Government Departments, and might not be obtainable commercially at such a low figure as was actually paid.

Each kiln has a capacity of 1,700 ripe nuts, which produces approximately 0.3 of a ton of copra in three days, or 36 tons per annum. As this product commands a premium in open competition of upwards of £1 per ton over the locally prepared native product, it is evident, provided that the kilns can be kept working

continuously, that the initial outlay is quickly recovered.

It is not possible to give any satisfactory estimate of the costs of production under estate conditions, as the amount of labour required to work a block of two kilns is sufficient for a larger unit. It is suggested, however, that for a block of four kilns an allowance of one man per kiln during the daytime, with one general watchman at night, would be ample.

It may be mentioned that the judicious use of the husks and shells from any given number of nuts, plus the usual plant refuse to be found in the plantation, provides sufficient fuel to convert those nuts into copra, and that additional fuel from outside sources does not have to be supplied.

As indicated in the foregoing paragraphs, the work being carried out in Dar es Salaam is entirely experimental, and progresses very slowly, owing to the very limited supply of nuts available for this work. The most important information which it is hoped to obtain concerns the shortest length of time in which the copra can be manufactured without detriment either to its appearance or to its oil content. To this end, experiments are being carried out in which, by regulating the heat, copra is being dried over different periods, and samples submitted to the Government Analyst for determination and comparison of the oil content of the finished product. It may prove to be that the extra small percentage of oil obtained by very slow drying will not outweigh the advantages of increasing the annual capacity of the kilns which would result from a quicker drying, and that the very best quality copra will not necessarily be the most profitable and economical to produce.

It is a necessary condition of the adoption of kilns on the large scale which it is hoped to secure that they should be both simple and inexpensive to construct. If this condition can be fulfilled it should be possible, in the case of medium-sized estates, to erect one kiln or one pair of kilns in every fifty-acre block of trees, thus, amongst other advantages, eliminating the cost of transporting nuts to a central site. In the case of small native holdings, there are a variety of ways in which kilns could be brought into general use. Doubtless the best is that which is now receiving increasing support by the natives in Malaya, where a number of smallholders join together in erecting a kiln. Each member sells his nuts to the kiln at the current market rate, and the copra produced is sold to a dealer. A practical alternative is the erection of kilns either by native treasuries or by private enterprise. Such kilns would be leased, and the lessee enabled either to purchase outright nuts brought to the kiln or to manufacture the copra on a commission basis.

A beginning has been made in the introduction of kilns into the Dar es Salaam area by the insertion into the lease of the various Government properties of a clause requiring all copra manufactured from the plantations to be kiln dried, and a block of kilns is now under construction for this purpose.

First Steps in Planning a Holding for a Native Farmer

By C. E. J. BIGGS, *B.Sc. (Lond.), Dip. Agric. (Wye), Senior Agricultural Officer, Uganda.*

While it is possible to design an agricultural holding for an African from information contained in crop acreage returns, these statistics only give average areas *per capita,* and do not give any idea of the agricultural economy of the family. It is necessary to know the family's means of subsistence, and its method of raising money. The size of the family and the working capacity of its members are important considerations, varying as they do among different tribes. And as it has been accepted that the best results are obtained in Africa by improving existing methods, rather than in attempting to impose entirely new ones, it becomes the more important to find out the family outlook.

The two "agricultural surveys" on which this paper is based illustrate what a diversity of useful information can be obtained by an intensive study on the spot. Each survey was carried out in one *mutalla* (a small administrative unit), and the time devoted to each was only ten days.

One survey was made in Busoga, where the chief characteristic of the vegetation is elephant grass (*Pennisetum purpureum*), and the staple diet is the plantain; and another in Bugwere, which is a short grass (up to 4 ft. high) country, populated by grain-eating people.

Provided that the chief object of the survey was attained—to find the area of land under crops raised by families—the investigator was allowed to choose his own method of reaching it. As a result, the side-lines produced as much useful matter as the main track.

AGRICULTURAL SURVEY OF A *Mutalla* IN NAMUNGALWE, BUSOGA DISTRICT.

The population of the *mutalla* was found to be 750 persons, being 219 men, 256 women, and 275 children. These 750 people live in 168 households. While in general the household consisted of the householder and his family, in others there were his friends, brothers, father, mother, or hired labourers. In two cases, old women were found living by themselves, and these were counted as householders.

The population was remarkably homogeneous; out of 168 householders there were 3 Baganda, and 2 Banyaruanda, the remaining 163 being Basoga.

The whole population was engaged in agriculture, but thirty householders had some additional occupation. This *mutalla* is situated at the headquarters of a larger administrative unit, the *gombolola.* For this reason, there were 11 householders coming under the description of chiefs.

(*a*) Householders with no other occupation than agriculture		138
(*b*) Householders not wholly engaged in agriculture—		
Chiefs and Headmen ...	11	
Craftsmen—		
Roadmaker	1	
Carpenter	1	
Smith	2	
Basket-maker	1	
Other Occupations—		
Dispenser	1	
School Teachers ...	4	
Lorry Drivers	3	
Herdsmen	6	
		30
Total Householders ...		168

The herdsmen, two of whom are Banyaruanda, grow little or no food crops. They are paid in milk, which they barter for food. The lorry drivers are occupied during the cotton marketing season only.

There are two sub-grade schools in the *mutalla*, one Roman Catholic and one Protestant, and these have been attended by 34 householders, or 21 per cent of the population. There is also a Mohammedan school, but figures of attendances are not available.

Crops Grown in the Mutalla and their Acreage.

During the survey all plots were paced out by native staff. At the same time, the previous cropping of each plot was recorded. All householders did not grow all crops, and in the following table the area per family has been adjusted accordingly.

	Total Acres.	Area per Household.
Cotton	318	1.89
Plantains	288	1.80
Sweet Potatoes ...	44	0.26
Cassava	4	0.06
Millet (Eleusine) ...	71	0.47
Millet (Sorghum) ...	2	0.12
Maize	16	0.03
Groundnuts	44	0.26
Bambara Groundnut ...	10	0.20
Cowpea	13	
Beans	5	
Simsim	4	

Rotation of Crops.

The main food supply comes from the plantain gardens, which are more or less permanent. It appears that not more than 5 per cent of the plantain area is replanted each year, and it was said that more than 50 per cent of plantain gardens were over twenty years old.

In among the bananas are planted fruits, vegetables, and auxiliary crops. A record of these crops and the percentage of householders growing them follows.

	Percentage.
Paw-paw	80
Citrus	59
Mango	39
Pineapple	44
Guava	8
Chillies	80
Marrows	74
Tannias	52
Yams	21
Sugar Cane	11
Tobacco	6

The high figure for citrus and paw-paw was unexpected.

The root crops were found not to be grown in a rotation but in an assembly of plots near to marshy land.

The area of grain and leguminous crops grown in the second rains was very small. In general, they appear to be planted early in the year, are harvested in June and July, and are followed by cotton.

The cotton plots were measured, and their previous history analysed in detail.

Previous Cropping of Cotton Plots.

	Percentages.	
Cereals—		
Millets	22.7	
Maize	4.9	
		27.6
Legumes—		
Groundnuts	14.1	
Voandzia	3.1	
Cowpea	4.2	
Beans	1.5	
		22.9
New Land		41.6
Miscellaneous—		
Sweet Potatoes ...	3.9	
Cassava	1.1	
Simsim	1.3	
Plantains	0.6	
Fallow	1.0	
		7.9

These figures indicate a rotation of cotton, food crops, cotton, roughly two-fifths of the cotton being planted on

newly cleared land or brought into cultivation after resting, and three-fifths planted after the harvesting of the food crops.

The Size of the Family and the Area of Crops.

This effect was observed on the money crop (cotton) and an important food crop (sweet potatoes): —

Family.	Area in hundreds of square yards. Cotton.	Sweet Potatoes.
Man	68.0	1.32
Man, woman, children	82.5	9.04
Man, 2 women, children	103.0	14.10
Man, 3 women, 1 child	111.0	31.90
Man, and more than 3 women, and children	126.0	46.10

It appears that when a man gets married he stops doing much work himself. One wife only adds 25 per cent to the cotton area, and the proportion decreases with the third and fourth wives. On the other hand, the sweet potato area increases rapidly. A single man grows very little, but in families the extra wife always grows more sweet potatoes, though she may not grow cotton.

Live Stock.

Number of live stock: Cattle, 300; goats, 468; sheep, 71; fowls, 1,101.

The cattle do not affect agricultural practices. They are grazed in the less fertile parts of the *mutalla,* in charge of the herdsmen. The goats and sheep are kept near the houses, and are looked after by small boys.

There are no ploughs.

AGRICULTURAL SURVEY OF A *Mutalla* IN KACHUMBALA, BUGWERE DISTRICT.

In this survey, attention was directed to the effect of ploughing on agriculture. In contrast to Namungalwe, the cattle population is numerous, the country suitable for ploughing, and the staple food is grain.

Population.

Although this area is regarded as a Teso area, the population included 18 per cent of other tribes, made up of Bagwere, Bagishu, Baganda, Banyuli, Basoga, Banyoro, Badama, and Bakamba. There were 252 families. As the size of families differs, a "man power" figure was calculated for each family. Thus a family of one man, two wives, and three children would have a man power figure of 1 plus 2 plus 3 halves = 4½. The Teso families wholly engaged in agriculture numbered 193, and the following observations are confined to these families.

The Effect of Ploughs on Acreage.

The total area of cotton in the *mutalla* was 668 acres; and the total area of cereals was 833 acres.

(*a*) *Ploughs.*—There are 36 ploughs in the *mutalla,* owned by families containing a total of 46 men, with a total man power of 146 units.

Crop.	Total Area.	Area per Man Power.
Cereals ...	312 acres ...	2.13
Cotton ...	193 acres ...	1.32

(*b*) *No Ploughs.*—The total man power of non-plough owning families was 466 units.

Crop.	Total Area.	Area per Man Power.
Cereals ...	521 acres ...	1.10
Cotton ...	475 acres ...	1.02

Increase in area of cereals due to ploughs = 93 per cent.

Increase in the area of cotton due to ploughs = 32 per cent.

Non-plough owners had 1.4 women per man, and plough owners 1.6 women. It was possible therefore that the increased area among plough owners might be due to a higher proportion of women doing more work than men.

Non-plough Owners.

No. of Families.	No. of wives per man.	Average area of cotton per family.	Area per person.
15 ...	0 ...	2.1 ...	2.1
64 ...	1 ...	2.43 ...	1.2
31 ...	2 ...	3.29 ...	1.1
3 ...	3 ...	2.2 ...	0.7

Plough Owners.

No. of Families.	No. of wives per man.	Average area of cotton per family.	Area per person.
3	1	3.8	1.9
7	2	3.8	1.3
2	3	3.6	0.9
1	8	11.4	1.3

The greater energy shown by bachelors may be accounted for by their youth and strong incentive to obtain money to get married. It appears also from the figures that no man spends money on a plough until he has first obtained a wife. A further analysis of the figures showed that Christians have fewer ploughs and cattle than pagans, probably because Christians are younger men who have not yet accumulated wealth. Also, among ploughing families, more of them grew groundnuts, and the plots were larger than in non-ploughing families. With cowpeas, which were planted by every family in this *mutalla*, there was again a larger area in plough-owning families.

Areas of Land Required to Support Families in Bugwere and Busoga.

From the results of the surveys which have been briefly described, information has been obtained upon which to design an agricultural holding for a native of each of the districts surveyed.

(*a*) Land required for Busoga families: Assuming the family to be one man, two women, and children:—

	Acres.	Acres.
Plantains		2.00
Sweet Potatoes		0.29
Cotton—		
(*a*) On new land	0.85	
(*b*) After cereals	0.64	
After groundnuts ...	0.32	
After other legumes ...	0.32	
		2.13
Cassava and small crops grown in late rains ...		0.25
Total area ...		4.67

(*b*) Land required for Bugwere families: Assuming the family to be:—

(1) Non-plough owner, with one wife and two working children:

	Acres.	Acres.
Cereals		3.57
Following cereals on same land—		
Cowpea and Beans ...	1.40	
Sweet Potatoes ...	0.20	
Cassava (if grown) ...	0.78	
Simsim (if grown) ...	0.02	
Cotton (total, 3.27) ...	1.17	
Cotton on new land ...		2.10
Groundnuts on new land ...		0.36
Total area ...		6.03

(2) Plough owner, with two wives and two working children: This family follows the same rotation but grows more cotton, groundnuts and cereals, requiring a total area of 9.5 acres.

Conclusion.

Land which has been in cultivation must be allowed resting periods, either fallow or under grass; manuring and possibly grazing may be introduced into agricultural practice. The "total areas" given represent the land in use every year, to which must be added the area found necessary to provide for such restorative measures.

Acknowledgments.

This paper is based on work carried out by Mr. T. R. Hayes and Mr. R. K. Kerkham in the course of duty.

Household Sprays

By R. R. LE G. WORSLEY, *Ph.D., Biochemist, East African Agricultural Research Station, Amani, Tanganyika Territory.*

The use of paraffin sprays in the home against mosquitoes, flies, cockroaches, etc., is now fairly universal, and the purpose of this article is to describe how such sprays may be made at home, both easily and comparatively cheaply, from materials obtainable in East Africa.

Household sprays consist of kerosene, in which is dissolved some substance toxic to insects; in addition, a perfume may be added if desired. These constituents will be considered separately.

Kerosene.

Paraffin oil for burning in lamps must be used. Power kerosene should not be substituted for this, as its flash-point is too low, and an explosion is liable to occur if it is sprayed near a naked flame. Even lamp paraffin should not be sprayed near a flame.

The kerosene should be of good quality and clean, the least odorous brand being chosen when possible.

Toxic Principle.

Pyrethrum is the most effective toxic substance, and as it is now grown in Kenya and parts of Tanganyika it can usually be obtained without trouble.

Other plants, however, may be used, and where these are grown locally they can be employed as efficient substitutes for pyrethrum. Of such plants, *Derris elliptica* is the best; the roots are used, the fine roots being somewhat more toxic than the coarse ones. Another suitable plant is *Tephrosia vogelii,* which, incidentally, makes a very good cover crop; the leaves or the seeds are used in this case.

Pyrethrum has the one great advantage over all other similar insecticides of producing a very rapid stunning effect; within a few minutes of being sprayed, insects have been brought down and are more or less paralysed, remaining in this condition for several hours before eventually dying. In the case of Derris and Tephrosia sprays, the immediate effect is less apparent, but in a short time the insects will be found to be affected and they will eventually die, frequently in a shorter period than with Pyrethrum.

The following experiment, carried out by the writer, will illustrate the toxicity of the three substances. Cockroaches were dusted with equal amounts of the three powders and put on one side for observation. After ten minutes, all those dusted with Pyrethrum were on their backs, kicking violently, but unable to turn over; the others dusted with Derris and Tephrosia were very agitated, but otherwise apparently unaffected. After two hours, the Pyrethrum-dusted ones were still kicking violently, and the Derris ones were obviously much affected, as they frequently fell on their backs, and had difficulty in turning over again; after four hours the Tephrosia-dusted ones were seriously affected. After twenty-four hours the Derris ones were all dead, the Tephrosia ones very seriously affected, and the Pyrethrum ones were still all alive and kicking feebly. The Tephrosia ones were dead after forty-eight hours, but the Pyrethrum ones did not die until after seventy-two hours.

Similar results have been obtained with kerosene sprays, and these results show that where Pyrethrum is not available Derris or Tephrosia may safely be substituted. The result of spraying insects with these last two may not be so spectacular as with Pyrethrum, but the final effect should be the same with most insects (cockroaches will probably require somewhat more spray than when Pyrethrum is used), and mosquitoes and flies,

although not paralysed so rapidly, will, nevertheless, be too occupied with the spray's effects to cause much more trouble.

Perfume.

Most people dislike the odour of kerosene when sprayed around the house, and to counteract this various perfumes may be added. Most of the strongly scented perfumes are suitable, and the following can be recommended: Oils of wintergreen, lemongrass (or verbena), clove, geranium and eucalyptus. The amount required is about three ounces to the gallon of spray.

Preparation of the Spray.

Whichever plant is employed, it must be air-dried, i.e. dried by exposure to the air. Pyrethrum flowers and Tephrosia leaves and seeds are dried whole, whilst Derris root is first of all cut up small. Artificial heat should not be used, as this tends to destroy some of the toxic substances.

The material, especially in the case of Pyrethrum, should be used as soon after drying as is possible. It is ground up finely, and extracted with the kerosene in the following simple manner: Place half a pound of Pyrethrum or Derris or one pound of Tephrosia seeds or leaves in a *debi* or other suitable vessel, and pour on to it one gallon of kerosene. Stir vigorously for about a minute, and then leave for twenty-four hours, with occasional stirring. The kerosene, which will have extracted the toxic principles, must then be filtered off. This is accomplished by pouring the stirred-up mixture through fine muslin or *americani*, etc., or through blotting or filter paper. As much kerosene as can be is then squeezed out of the powder (the powder will retain about three-quarters its weight of kerosene), and sufficient fresh kerosene is poured through it to make the volume of filtered spray collected up to one gallon.

Care must be taken that none of the powder passes through into the spray, otherwise the spraying machine may become choked.

To the filtered spray any perfume required is then added and stirred in. Pure oils must be used, not scents made up in alcohol, as these are insoluble in kerosene.

Storage.

These sprays, especially Pyrethrum, must be stored away from light and heat. Tins or amber-coloured bottles are suitable, but blue, green or clear bottles must not be used. The containers should be kept as full as possible, and be stoppered. Exposure to light and much air or heat causes destruction of the toxic principles in the spray.

Summary.

Efficient household sprays can be made by using half a pound of Pyrethrum or Derris, or one pound of Tephrosia seeds or leaves to one gallon of lamp kerosene. Three ounces of perfume may be added to this to disguise the odour of the kerosene.

Virus Diseases of East African Plants. I.—Introduction

By H. H. STOREY, *Ph.D., Plant Pathologist, East African Agricultural Research Station, Amani, Tanganyika Territory.*

The word "virus" is now familiar to most readers. As the causative agents of diseases affecting man, domestic animals and crop plants, viruses are now recognized as of great importance. In this first of a series of articles upon the virus diseases of East African crop-plants, I shall attempt to indicate the general outlook of the research worker upon the problem; to show what is known of the nature of viruses, and thence to deduce the principles of the methods by which they may be controlled in agricultural crops.

I do not attempt to answer the question as to what is the ultimate nature of a virus. That is a mystery to which science has at present no certain answer. We know, however, some of the properties of viruses; we know something of how they act; and in the following paragraphs I shall consider, point by point, these items of knowledge, and indicate their bearing upon practice.

I.—A Virus is Invisible.

The majority of the diseases of plants can be attributed to the attack of parasitic organisms that can be studied and recognized. Many attempts have been made to attribute virus diseases to microscopically visible organisms, but without success. Probably this character of invisibility is due to the minute size of the virus, for many are known to pass freely through filters that hold back the smallest visible bacteria. Yet a filter with pores of a certain maximum size may retain a virus; so that we must suppose that the virus exists as particles, but so small that they remain invisible under the maximum possible magnification of the microscope. To picture the virus as a minute living organism is often useful, and will in practice rarely lead one astray. It is, however, far from certain that the virus is living matter in the sense that we now understand the term.

II.—A Virus is Recognizable only by its Effects.

As the virus itself is invisible, we can know it only by its effects; that is, by the disease symptoms it produces. This point adds very greatly to the difficulties of the pathologist, for several viruses may produce similar symptoms, and the symptoms of one virus disease may vary under different conditions. The mycologist will usually confirm the diagnosis of a fungus disease by study of the fungus concerned. No such procedure is possible with a virus disease. The pathologist must rely on the signs in the plant alone; he must see the plant in the living condition, since the characteristic symptoms often disappear if the plant be preserved; frequently he must subject the suspected plant to prolonged study and experiment before his diagnosis can be certain.

In general, however, the symptoms of virus diseases are characteristic. Their outstanding effect is the prevention of the formation of the green pigment in the leaves. So we get a general yellowing of the new foliage, as in groundnut rosette disease; or an incomplete suppression of the chlorophyll, giving a somewhat irregular mottling, as in mosaic diseases of tobacco, cassava, sugar cane and maize; or, again, instead of a mottling, we may find colourless or yellow areas in a definite pattern, such as the narrow stripes along the veins of maize and sugar cane suffering from streak disease. Sometimes the green and yellow parts of the leaf grow unevenly, so that the leaf becomes puckered, twisted and misshapen. But there are other causes of yellowing of

foliage, particularly nutritional causes; while an experienced pathologist may recognize certain points of difference in the symptoms due to the two types of cause, he may often be in doubt. For example, the yellows disease of Nyasaland tea was at one time suspected to be a virus disease; but investigation proved the cause to be solely a shortage of sulphur in the plant.

Another type of symptom is that found in virus diseases of cotton (in the Sudan and Nigeria, though not certainly in East Africa), tobacco and a number of indigenous weeds, where the leaf-veins grow out on the lower surface into dark-green protuberances, sometimes as frills or cups, but more usually merely thickening the veins and causing them to show as dark-green lines upon the paler green under-surface of the leaf. This abnormality is accompanied by more or less curling and twisting of the leaves, so that this group of diseases has come to be known as "leaf curl"—a not very suitable name, since the outgrowths and not the curling are the feature that serve for diagnosis of the virus disease. Another type of virus disease, such as leaf-roll of potato, shows however curling of the leaves as its only characteristic feature.

All these symptoms are accompanied by more or less stunting of the plant and sterility of its reproductive parts. They are features of no significance in diagnosis, but their importance in diminishing the useful yield to the planter needs no emphasis.

The death of parts of an affected plant, the usual accompaniment of a fungus or bacterial disease, is unusual among virus diseases. Certain viruses, however, particularly among those attacking tobacco, tomato, and potatoes, may in some circumstances produce brown dead areas on leaf and stem, simulating those due to visible parasites. Few viruses kill a plant outright.

Finally, there are instances where infection by a virus produces no symptoms in the plant whatever. Probably we are only on the fringe of knowledge of this phenomenon, for the difficulty in recognizing such a plant as diseased is very great. Yet there are well authenticated cases where an apparently healthy plant has been proved to carry a virus capable of producing a visible disease in another variety or species of plant. Thus, this matter assumes great practical importance; for a plant that appears entirely normal may be the source whence a virus is spread to a susceptible crop, with serious effects.

III.—A Virus is Entirely Dependent for its Existence upon Living Tissue.

The majority of the visible disease-causing organisms—fungi and bacteria—are capable of growing and developing on dead material, such as the mycologist's culture media. No virus has ever certainly been shown to multiply on anything but the living protoplasm of its host. It is true that a few viruses, and particularly that of common tobacco mosaic, may persist even for years in the juice extracted from a diseased plant, or in dried plant tissue. But here there is survival only, without multiplication. The majority of viruses disappear rapidly from a non-living medium, so that only in rare instances is there any danger of a crop contracting a virus disease from the debris of a previously diseased crop remaining in the soil.

Thus, for its survival, the virus is dependent upon the plant that it attacks. In the absence of that plant, the virus must disappear. To this generalization there is, however, one great exception. A particular insect can also act as a host of each virus. I shall return to the important relation that holds between the virus and the insect.

IV.—The Virus is Persistent in the Host Plant.

Once a virus has become established in a plant, it will continue to develop in that plant indefinitely. Minor exceptions to this rule are known, where plants have certainly recovered from a virus infection, the new growth being free from virus. But, in the great majority of cases, a virus-diseased plant will remain for the rest of its life virus-diseased. Furthermore, the virus will be present in every part of that plant—leaf, stem, root and flowers. The important practical bearing of this principle is upon the culture of those plants that are vegetatively reproduced, by cuttings, etc.; for every cutting from a diseased plant will itself produce a diseased plant, and the virus will persist indefinitely. Thus we see the importance in the planting of sugar cane and cassava of the selection of cuttings from entirely healthy plants.

To the principle of the universal distribution of the virus throughout the plant there are some exceptions. The important one is that, for some reason that remains obscure, the virus usually fails to penetrate, or at least to persist in, the true seed. Thus the seed from a streak-diseased maize plant will always grow into seedlings that are as disease-free as if the seed had come from a healthy plant. In general, crops grown from seed will start growth unhandicapped by virus disease. Again, however, there are minor exceptions; in particular, mosaic diseases of certain legumes may be carried in the seed.

V.—The Viruses are of Great Diversity.

A striking feature of recent virus research is the extent to which the list of known viruses has been augmented. It may be doubted whether there can be any end to the recognition of new viruses; it may even be questioned whether new viruses are not continually evolving. The complexity of the problem is therefore very great.

From the recent confusion certain principles seem to be emerging. We are coming to recognize two types of difference between viruses. In the first place, there is a large difference of kind, such as the difference between the viruses causing mosaic and streak in sugar cane, or between those causing mosaic and leaf-curl in tobacco. Here the difference lies in the character of the symptoms produced in affected plants; in some instances, we may demonstrate certain other differences residing in the viruses themselves, such as their ability to survive heating to certain temperatures and their resistance to other kinds of treatment. A further criterion available is a study of the range of plant species that may be infected. By such means we may arrive at a conception, as it were, of "species" of virus.

But when we examine a number of viruses supposedly of one "species" we find that they are not all identical in every respect. So we are led to recognize "strains" within the "species". For example, both maize and sugar cane may contract streak disease; the symptoms in each plant are similar, and one species of insect can transmit the virus from either. But the virus from maize cannot be caused to infect cane, while the virus from cane produces only a mild form of the disease in maize. The most reasonable explanation of this is that there are two strains of the streak virus specialized to the two host plants. Evidence is beginning to accumulate to show that there are several strains of the virus causing the mosaic of cassava.

It may well be asked whether these virus strains are stable and not constantly undergoing transformation one into another. Up to a point undoubtedly they are stable; under experimental conditions a single virus will usually remain notably constant in its effects. Nevertheless, in-

stances have been recorded where certain treatments have altered a virus and produced a recognizably distinct strain. Furthermore, there is reason to suspect that in nature new strains may be evolving, strains adapted to particular species or varieties of plants.

With such multiplicity of viruses, it must often happen that a plant becomes infected with more than one. Their interaction within the plant may give different results: (*a*) The symptoms of the two diseases may be produced simultaneously; for example, a sugar cane leaf may show the symptoms of streak and mosaic superimposed, as it were, one upon the other. (*b*)The combined effect of the two viruses may be a disease different in character from that of either alone. Many of the virus diseases of potatoes are now known to be caused by mixtures of viruses. (*c*) One virus may immunize the plant against the other. This principle has only recently been demonstrated. It opens up important possibilities for control, for it has been shown that a mild strain of a virus, producing only insignificant ill-effects on a plant, may protect that plant from more severe strains.

VI.—Viruses are Dependent upon Insects for their Transmission from Plant to Plant.

In general, no method is known whereby a virus in nature is transferred from one plant to another, except by insects. Each virus is, as a rule, adapted to only one or a few species of insects—other species are unable to transmit it. Exceptionally, one virus may be transmissible by a large number of different insects, or again one insect-species may transmit many viruses. But in most cases the virus is even more specialized in its relation with the insect-transmitter than it is with its plant-host. In a few instances, the insect is known simply to carry the virus on its mouth parts. Usually the process is a more complicated one; the insect takes up the virus by mouth in feeding on a diseased plant; then, after a time, the insect begins to inoculate the virus into other plants upon which it may feed—the virus being probably carried into the plant in the saliva—and the insect may continue this process until its death. The relation between virus and insect is thus a close one; the insect, no less than the plant, may be regarded as virus-infected, even though its appearance and behaviour give no evidence of this state.

In the absence of the suitable insect, a virus disease will not spread. It is true that there are various methods by which some viruses may be experimentally transferred, but these are methods that do not operate in nature. It is also true that there are a number of virus diseases for which no insect-transmitters are known, although undoubtedly they spread. Perhaps this is merely an instance of our ignorance, and future research may find the insect; or perhaps there is some other method of natural transmission of which we know nothing. There is one important disease where probably no insect is concerned—the common mosaic of tobacco. The virus of this disease is amazingly infectious; it can enter the plant even through a broken hair on the leaf. In the field the frequent outbreaks of this disease are generally explicable by the transfer of virus upon the hands or tools of workmen. But with this one exception, the plant-insect-plant cycle holds; if we can break that cycle, we can control the disease.

The foregoing consideration of the manner of action of viruses leads up to the principles of the methods by which they may be controlled.

(1) *We may grow only plants that do not contract the diseases.*—This is an obvious method of control, and a highly desirable one. Fortunately, resistant varieties of some crop plants exist or have

been developed by the plant-breeder. An outstanding example is the sugar-cane plant; recent breeding work in Java has produced varieties of good quality resistant to mosaic disease, so that our outlook upon the control of this disease has materially altered.

The foregoing remarks refer to the quality of *resistance to infection* by the virus. Instances are known where certain varieties of plants contract a virus disease freely, but are so slightly affected by it as to be still reasonably productive. The so-called "tolerant" sugar-cane varieties provide examples. Other plants, as we have seen, may show no ill-effects whatever from the virus infection. While plants of these two types may thus be grown successfully even though diseased, their use is generally undesirable, since they will act as sources of infection for any susceptible plants in the neighbourhood.

Control by the use of resistant varieties appears to be infallible. From an immediate point of view, that is probably true; but the danger that strains of the virus may evolve virulent to the previously resistant varieties is not entirely out of the question.

(2) *We may actively immunize the plants that we grow.*—I have already explained that a mild strain of a virus may confer immunity from severe strains. Perhaps in the future this principle may be applied in practice to the control of certain diseases; hitherto, however, it has received no practical application.

(3) *We may attack the plant side of the transmission cycle.*—We have seen that the virus cannot persist outside the plant or the insect. If there be no diseased plants in the vicinity of a crop, the crop cannot become diseased. There are several ways in which we may attempt to attain this end.

We may take steps to start with a healthy crop. If the crop be raised from true seed, this will normally be attained automatically. If the crop be raised from cuttings, the most careful selection of the planting material is necessary. Even so, a disease-free crop may not result, owing to: (*a*) transmission of the virus from neighbouring diseased crops, (*b*) transmission from surviving self-sown plants that may be diseased, (*c*) transmission from weed-hosts of the virus, (*d*) infection by insects that have survived from a previous diseased crop.

These considerations lead to further measures that may be taken. A virus will to a large extent disappear if there be a long close-season during which the crop is not grown. But then steps must be taken to destroy all self-sown plants during the close season. This procedure is highly effective in the control of streak of maize in Natal; it was also found to be effective in controlling rosette in groundnuts in the Transvaal during those seasons that followed a winter severe enough to have killed out all the self-sown groundnut plants.

Much may be done in some instances by the eradication of weed-hosts of viruses in the vicinity of cultivated lands. But, unfortunately, our knowledge of the host-range of many viruses is too imperfect to allow of an effective prosecution of this policy. Clearly the greatest danger comes from those perennial weeds that continue to grow diseased season after season. When our knowledge allows, a selective weeding of the dangerous species from the area adjacent to a crop may be a practicable procedure.

(4) *We may attack the insect side of the transmission cycle.*—Direct measures to control the insect-transmitter, such as spraying, are effective only under certain special conditions, e.g. in greenhouse crops under temperate conditions. Normally, an attack upon the insect, even if feasible, will fail to control a virus disease; for such an

attack will never effect a complete extermination of the insects, and even a few survivors may spread the virus extensively. Indirect control, by providing conditions suitable to those natural agencies that keep insect-multiplication in check, may prove of importance in the future. At present, we know of one instance only where virus control appears to have developed along these lines. Close planting of groundnuts in Uganda, Tanganyika and West Africa has been proved to reduce very materially the rate of infection by the rosette virus. While the explanation of this observation is not certain, I believe it to be as follows: The aphid species that transmits the virus is subject to the attacks of a fungus. With open planting sufficient aphids escape the fungus to carry the virus extensively through the crop. The effect of planting closely is to alter slightly the climatic conditions among the foliage of the groundnut plants. This slight change gives the fungus the upper hand, and the aphids are then kept in check.

When we compare the methods for the control of virus diseases with those available for other types of plant disease we recognize two striking points of difference. In the first place, virus control is comparatively simple, owing to the dependence of the virus upon living tissue, and its inability (in most cases) to survive in dead material. On the other hand, virus control has features of especial difficulty, owing to the persistence, wide host range, diversity, and perhaps adaptability of the virus. In some instances, the control measures now known to us have proved notably effective; in others, their relative failure is due probably to no error in the general principles but to lack of knowledge or opportunity for their proper application. At present, we are in an era when plant viruses on the whole have outrun both the research worker and the agriculturist. They present indeed to-day the outstanding problem of plant pathology.

Organization of the Production of Fire-cured Tobacco by Natives in Bunyoro

By G. T. PHILPOTT, *Tobacco Officer, Uganda Protectorate.*

Tobacco calls for far more care and attention than the general run of crops grown by natives, and the introduction of tobacco cultivation to the Banyoro represented a considerable advance in agricultural practice for a people who, from an agricultural point of view, had been regarded as one of the most backward in the Protectorate.

The climate over the greater part of Uganda is such that tobacco, and most other crops, can be planted with some degree of success practically the whole year round, with the exception of the dry spell which is fairly general from about the middle of December to the end of February.

To obtain the best results with tobacco, however, it is necessary that the seed should be sown at such a time that not only are plants available for planting out during a rainy period, when transplanting can be safely done, but climatic conditions during the whole of the growing, ripening, harvesting, and curing periods must be studied, and sowing done at the right time to produce plants which will be just at the right stage of growth to gain advantage from every slight change of conditions which may be anticipated.

A study of the growth of the tobacco plant reveals that, under normal conditions, roughly five to six months are required for the full development of the plant, from sowing time until the leaves are ready for harvest; the plants being roughly eight weeks in the nurseries before being large enough for transplanting, and from twelve to fourteen weeks in the field.

For the production of good heavy leaf it is desirable that ripening should take place during fairly dry weather, but it is undesirable that excessively dry weather should occur during the curing period.

In considering these points in conjunction with climatic conditions in Bunyoro, it was decided that the short dry spell which usually occurs in July would probably be the most suitable time for ripening the crop. Conditions during August are generally favourable for successful curing, and, as good rains for planting can usually be depended upon early in April, the first week in February was decided upon as likely to prove the most suitable time for sowing.

An important consideration, which makes it imperative that sowing should not be delayed, is the occurrence of hail, which may be expected with the breaking up of the dry weather in July. Hail may occur at other times, but when the plants are small the damage from hail is not serious; a hail-storm on a field of almost mature tobacco, however, generally means a dead loss.

The crop is a quick one, and apart from risks from weather conditions a little delay in carrying out any of the operations in connection with its production may mean all the difference between success and failure. Time is an all-important factor, and there is little doubt that the failure of tobacco experiments in Uganda in the past can be attributed largely to failure to realize this.

It is in this direction that one of the greatest difficulties has been experienced with regard to the organization of tobacco-growing by natives, who are accustomed to a very elastic calendar for planting operations, and wholeheartedly support the happy maxim, "Take no thought for the morrow." Even after some years of experience, and although they are keen on the crop, it is only with

the greatest difficulty that they can be persuaded to look forward and anticipate events by having their plots ready before the young plants have become too large for transplanting, or their barns ready for harvesting before the crop has become overripe. Heavy losses occur each season owing to failure to have things ready at the right time.

It was not until successful experiments had been carried out by the Department of Agriculture that any attempt was made to encourage tobacco-growing amongst the natives. From the start it was realized that markets are by no means unlimited, and that quality is of the greatest importance if the crop is to succeed. The experimental plots served as a demonstration which was keenly watched by the natives, and an early opportunity was taken to train a number of lads with a view to their being sent out as instructors to assist in the control and supervision of the crop in the field.

At the commencement it was hoped to develop the industry on a communal, or, rather, semi-communal, basis. Under this scheme, growers would cultivate their own plots, as near together as possible, but all other operations were to be carried out communally, each grower eventually marketing the produce from his own plot. It has been found impossible to develop along these lines, however, as individuals cannot be depended upon to take a fair share of the work, and, in a great many cases, a grower would disappear as soon as an operation had been carried out on his own plot, and would not assist in carrying on the work on other plots; and the only operations which it has been found possible to continue on communal lines are the preparation and care of the nurseries and the erection of curing barns.

By insisting that these operations are carried out by groups rather than by individuals, complete control has been kept over the nurseries and planting, and the supervision of curing operations is facilitated.

One of the greatest dangers which has had to be guarded against is over-production, and plantings are strictly controlled to provide only approximately the amount for which a definite market can be seen. Bunyoro has been gazetted a "declared area" under the Native Produce Marketing Ordinance, within which tobacco may only be purchased under licence. Previous to any seed being sown, a notice is issued in the Official Gazette asking for applications for licences. Each applicant must state what quantity he is prepared to purchase, and plantings are restricted accordingly.

Nurseries are established at convenient centres to serve groups of from ten to fifty or more growers. Sites are cleared, dug, beds made up, and shading materials collected under the supervision of the instructors. Acreage is estimated at the rate of one-third of an acre per man, that being a convenient-sized plot for one man to plant, harvest, and provide barn space for; but where large families are concerned a grower is allowed to put in two or more plots, according to the assistance he can command.

In order to provide a plentiful supply of plants, roughly ten yards of seed-bed are allowed for each grower. Seed is issued by the Department of Agriculture, and is sown by the instructors, who, with the assistance of the local chief, arrange for certain men to attend each day for watering, weeding, etc. Watering-cans are lent to each nursery by the Department of Agriculture, and, generally speaking, the beds are very well looked after and neatly kept.

As soon as the seed is sown, a commencement is made with the preparation of plots. Surprising difficulty has been experienced with regard to planting, but when one considers that there is not a

single native crop which has to be so handled, the difficulty is explained.

So far as the Banyoro are concerned, the nearest operation to planting to which they are accustomed is the setting of sweet-potato cuttings, which consists of loosely burying the cuttings in the soil, and great difficulty has been found in teaching growers not to bury the young tobacco plants too deeply and to properly "firm" the soil around the young roots. Very heavy losses occur each season at planting time, owing to bad planting.

As soon as it is considered that all growers have had ample time to finish planting, and with due consideration to the state of the nurseries and weather conditions, an order is issued that all plants remaining in the nurseries must be uprooted and destroyed, and no further planting is allowed. This is done partly to make growers realize that they must prepare their plots in time and partly to prevent over-planting, as it is found that growers are inclined to keep on enlarging their plots and continue planting so long as plants can be obtained.

As soon as possible after planting is finished, a start is made with the erection or repair of curing barns. The sheds consist of grass buildings, usually sixteen feet wide, and long enough to house the crop from ten to fifteen plots. They are built as high as possible, the actual height depending largely upon the length of poles obtainable in the immediate neighbourhood. Large sheds are discouraged, owing to the danger from fire during curing operations.

In the meantime, field operations such as priming, topping, suckering, etc., are carried out under the direction of the instructors. Growers are gradually beginning to realize the value of these operations, which at first were regarded with considerable suspicion.

Harvesting usually commences about the end of June or early in July, and it is at this stage that the value of early preparation of plots and the stoppage of planting at a given date becomes apparent. When only a small quantity of leaf, say the first pickings from only one plot, is available for harvesting, it is difficult to handle in the curing barn, and seldom cures out well.

Successful curing depends very largely upon atmospheric conditions within the curing shed. During the early stages of curing a fairly moist atmosphere is desirable, and the moisture given off by the leaves themselves naturally has some bearing upon the moisture content of the air in the barn, and, generally speaking, when only a small quantity of leaf is hung in a barn it dries out too quickly.

When all plots in a group have been prepared early, and planting done within a few days, the crop ripens evenly, and harvesting commences on all plots at about the same time, giving a reasonable quantity of leaf to be handled; but when, as far too often happens, plantings have been carried on for some time, the crop is uneven, and greater difficulty is experienced with harvesting and curing.

After harvesting, the leaf is allowed to hang in the barn until it becomes yellow. Small fires are then started on the floor of the barn and the shed kept full of smoke. The fires are allowed to die out at night time, and are restarted each morning until the tobacco is dry.

Curing is generally carried out communally, each group of growers dividing themselves up, so many to cut firewood, and two or three to look after the fires. Here again one meets with difficulty, owing to the unreliability of individuals. Often, when visiting a barn, one finds that the men in charge are keeping plenty of smoke in the particular part of the barn where their own tobacco is hanging but entirely neglecting the rest, and it is not uncommon to find that the men supposed to be bringing firewood do

not turn up. It sometimes happens, too, that the men in charge will start the fires and then leave the barn unattended, and a fire, flaring up, sets fire to the tobacco, and the whole barn is destroyed, causing a heavy loss to the members of the group through the irresponsibility of one or two persons. During the last two seasons, buyers of native-grown tobacco have been required to pay a cess of two cents per lb. on all leaf purchased, and part of the money so collected is now used to compensate growers who lose their tobacco in this way; a maximum of Sh. 15 being paid for the entire loss of tobacco from one plot.

For marketing, the leaf is graded into two grades. Prices are fixed at the beginning of the buying season, and a flat rate paid throughout the district. For export to the English market, the buyers have to re-grade all leaf. A certain amount of loss occurs during re-grading, but this is taken into consideration when prices are fixed and a fair allowance made.

The early shipments of Uganda tobacco to London and Liverpool were well reported upon by brokers and manufacturers as regards the quality of the leaf, but many complaints were received that shippers were packing with too high a moisture content, which not only affected the keeping qualities of the leaf, but also, on account of the very high import duties, made the tobacco too expensive to the manufacturers, who began to look with suspicion on all tobacco from Uganda.

In order to counteract this, and endeavour to establish an export market, Government has erected a small packing factory, and all native-grown tobacco purchased within the declared area of Bunyoro, and intended for export outside of East Africa, must pass through that factory, where it is reconditioned and packed with a moisture content of from 12 to 14 per cent. Manufacturers who have handled native-grown leaf from Bunyoro during the past two seasons have expressed complete satisfaction with the condition in which the tobacco is now being exported.

The successful introduction of the crop in Bunyoro has depended largely upon the work of the native instructors. The lads employed in this capacity have had a certain amount of elementary education and, on leaving school, do one or two seasons' work at the tobacco trial grounds in Bunyoro, where they have practical experience in carrying out all operations in connection with the crop, after which they are placed in charge of a certain area in the district.

Their work is by no means easy. They have no actual control of the growers, and they are very apt to become discouraged when, as often happens, their instructions are completely ignored. The people they are dealing with have had no previous experience of handling the crop, such as might be gained when working on a European estate where tobacco is being produced, and all instruction has to be carried out in the field, where there is no compulsion for anyone to attend.

The rapid increase in the production of fire-cured tobacco in Bunyoro is shown by the following crop figures:—

Year.	*Crop. Lb.*	*Value to Growers. Sh. cts.*
1927	1,631	427 00
1928	61,355	16,869 20
1929	138,017	35,412 90
1930	183,212	50,099 80
1931	403,508	99,882 90
1932	622,166	133,898 62
1933	768,804	147,610 10
1934	1,469,142	306,384 72

The leaf produced is of good quality, and has been described by brokers and manufacturers as quite equal to fire-cured tobacco produced in other countries.

The Cultivation of Sisal

By G. W. Lock, *Dip. Agric.*, *N.D.A.*, *District Agricultural Officer (Sisal), Tanganyika Territory.*

I.—Manuring in Relation to Sisal Cultivation.

The sisal plant has considerable inherent vigour which makes it adaptable to widely differing conditions of soil and climate. It demands the minimum of attention in the field. Consequently, wherever suitable land is plentiful, the course most commonly followed by planters for increased production is the straightforward one of enlarging the area under cultivation. These factors have directed sisal cultivation along extensive lines. They are also reasons why the question of manuring *per se* has seemed a remote one, and present knowledge on this subject happens to be rather vague.

The time has arrived, especially in the more concentrated areas of production where further alienation of land is not possible, when sisal estate owners have had to turn to old areas which have run out or are past their prime. Many of these old plantations have been replanted or regenerated by selected sucker growth, after having withstood unabated cropping for twenty years and upwards. It is not surprising therefore that signs of apparent soil deficiencies should be developing, particularly in association with poorer types of soil. The existence of a necessity for periodical manuring is by no means improbable, and this may become a recognized practice in the future.

"Banding" disease, or brown bands across the base of sisal leaves, finally causing their collapse, is believed to be related to some soil deficiency. The Mycologist, from his investigations in this territory, is satisfied that no parasite is the cause of the disease, and considers the ailment to be of a physiological nature. Affected plants transplanted by him to a fresh soil soon recovered and became normal. Moreover, manurial trials conducted by one planter in the Tanga district have indicated that the incidence of this disease can be reduced by the application of fertilizers. Stump rot, recorded on two estates, and again a leaf stripe that can sometimes be observed in sisal, are possibly other symptoms showing that absolute harmony does not exist in the relationship between the plant and the soil. A trial in connection with banding disease has already been initiated on an estate in the Tanga district, and another elsewhere in relation to stump rot disease.

Until further investigations have been made it is difficult to detect the exact minerals removed from the soil by sisal. Exhausted soils are generally lacking in some or all of the elements—nitrogen, phosphate, potash and calcium. Excluding soils of volcanic origin, other and older types frequently have low phosphate and potash contents, whereas organic matter decays rapidly and nitrates are easily leached from the soil in the tropics.

In the case of sisal, the chances are that an application of nitrogen would not fail to bring about an improvement in leaf size, but its greatest value may prove to be in helping the plant to recover from cutting. Sisal on well-drained silts rich in humus is superior to that on poorer soils, even though more closely planted. Secondary and tertiary sucker regeneration can produce useful leaf. Fibre yields are enhanced by the greater bulk of leaf obtained alone. On the other hand, nitrogen in excess can render plants more susceptible to disease, but this is

hardly likely to occur with sisal, where the existence of specific fungus diseases is so far unknown.

The supply of phosphates and potash is often inadequate in tropical soils. It has been reported that in Java applications of about 60 kgs. P_2O_5 and 40 kgs. K_2O per acre, according to soil, are made annually. Unfortunately, there is no mention of the value of such treatment, except that average yields range between 1¼ and 2 tons of fibre per acre pei annum. One function of phosphate is to encourage the development of roots, which in turn has a far-reaching effect upon the welfare of the plant. Sisal has a shallow root system which would fail the plant in the majority of dry seasons but for the resistance of its leaves.

Potash is known to give a stimulus to growth of sisal, as demonstrated by the effect of wood ash from burnings. It may also affect maturity and thereby play an important part in the development of fibre within the leaf.

The role of lime in the metabolism of the sisal plant is obscure. The leaf is known to contain calcium oxalate. Direct applications of lime on soils overlying coral limestones have given negative results. Yet sisal seems to show a preference for soils on these formations; fibre percentages are stated to be higher, and, despite long continuous cultivation, much of the sisal in coastal areas still maintains a healthy appearance.

In the trials mentioned previously, a twice repeated dressing of phosphate potash and lime to a poor sandy soil contributed materially towards the elimination of banding disease, besides making for larger plants. These manures by themselves or in pairs resulted in only slight improvement. It is quite possible that an interaction exists between all four plant nutrients, and that a balanced mixture of artificials is required before the maximum response is obtained. Manurial experiments with sisal should help in the elucidation of these problems.

Under the present economic conditions of the sisal industry, which are likely to prevail for some time yet, the cost of manuring may be prohibitive. Cheaper means will then have to be sought for rehabilitating the soil. The resting of sisal areas for one year might suffice, or the growing of a deep-rooted leguminous crop, such as one of the larger species of *Crotalaria*, pigeon peas (*Cajanus indicus*), or *Tephrosia candida*, which penetrate the soil in addition to providing a mulch, may achieve the desired result.

It will be seen that there are already indications that unlimited demands cannot be made on the soil by sisal, and the manurial requirements of the crop is a subject well worthy of careful examination.

II.—The Conservation of Soil Moisture.

Although the sisal plant is xerophytic with strongly marked drought-resisting properties, it is not to be doubted that soil moisture has a profound influence upon its development. Sisal grown in areas of relatively high rainfall, although sappy, recovers more rapidly from cutting than that planted under extremely dry conditions. The opening of the central spike can be correlated with rainfall by observation alone. After a long dry spell has been broken the yellowness of the uppermost leaves is sometimes very evident, indicating that the plants are responding to the beneficial results of rain. Root systems become active, and the plant has the means to absorb nutrients from the soil. In the tropics, a dry season is equivalent to a winter in temperate zones, when plant growth is more or less at a standstill, and so plant life in general has to make the most progress it can whilst sufficient moisture exists in the soil.

The sisal planter is mainly interested in the vegetative portion of his plant. A rapid output of good leaves is his requirement, for which growth needs to be sustained. The stage from planting out to maturity requires to be curtailed as much as possible. It is during this period that he may exercise most influence upon the development of sisal by improving the moisture-retaining powers of the soil when it is accessible for cultivation. Waterlogged conditions are well known to be inimical to sisal; in East Africa, these are usually obviated quite easily.

It has to be remembered that leaves, besides absorbing carbon dioxide from the air, also transpire moisture. When the transpiration rate exceeds that of the absorption of moisture by the roots, wilting occurs. Despite the protective character of its waxy leaf, such a phenomenon is not unknown in connection with sisal. It has been estimated that the water consumption of agaves represents a rainfall of 200 to 250 mm. per annum. When it is considered that only approximately 20 per cent of the total precipitation of rain in the tropics can be utilized, the remainder being represented by seepage, run-off and evaporation, the importance of conserving soil moisture is stressed.

From this standpoint, the management of sisal is bound to vary from one locality to the next. The drier the area the more exacting it becomes. Spacing immediately assumes a more important aspect, and it is obvious that rigid rules cannot be laid down applicable to all districts. On the basis of obtaining well-developed leaf, the lower the rainfall the wider planting distances should be made.

Cultivation methods are closely connected with soil moisture conservation. Weeds are perhaps detrimental not so much as regards the plant nutrients removed as from the competition for water. Conversely, a bare soil can become so hot and inactive that root growth is inhibited. Thorough initial cultivation has value which can be demonstrated wherever mechanical preparation of the land has been employed. Quick growth may be conducive to early poling, but a higher turnover of bigger leaves may result.

Shade keeps the upper layers of the soil cool and damp, evaporation is retarded, and the activity of soil organisms is promoted. Such protection is given by cover crops, preferably leguminous, since these add to the nitrogen content. A strong drought-resisting legume, possibly capable of suppressing weeds, often has drawbacks in being either a climber which smothers the sisal, or too bushy, giving excessive tall shade. So far, *Crotalarias* have been most promising; *C. usaramoensis* will establish itself on poor soils, and *C. invantulensis* will compete with weeds on volcanic soils, to which it is indigenous. Failing a cover crop, a dry mulch of weeds is better than an exposed soil, whilst even the latter may be more desirable than uncontrolled weed growth.

Vegetative Propagation of Coffee

By S. GILLETT (*Dip. Agric., Wye*),
Agricultural Officer and Experimentalist, Kenya Colony.

The reproduction of coffee by asexual methods has attracted attention in other countries, notably Java, for many years. Unforeseen difficulties have occurred, and although experimentation has been in progress for over fifty years, it cannot be claimed that the practical advantages of this method of reproduction have been fully appreciated until recent years. It is only to-day that some of the earlier problems are being elucidated, and it is obvious that a large field of work lies ahead of the research worker before many of the practical difficulties are solved and definite recommendations can be made.

In Kenya, a relatively recent coffee-producing country, it is quite natural that the subject has not been given earlier consideration. The possibility that many of our cultural problems might be more easily solved by breeding or selecting suitable trees and reproducing their offspring asexually is now realized, and, with this end in view, work on these lines was commenced three years ago.

Advantages and Disadvantages of Vegetative Propagation.

Before discussing the results obtained from the preliminary researches, it would be well to state the advantages and disadvantages of this method of reproduction. It will, it is felt sure, be obvious that the advantages are so great that the work is deserving of the fullest support.

The main factor upon which all other

FIG. 1.
Artificial Propagator, showing heated bottom chambers and overhead canopy.

advantages depend is ably stated by F. P. Ferwerda (1), who writes as follows: "The most important advantage is undoubtedly that the daughter-individuals produced exactly resemble in outward appearance both one another and the mother-plant." Enlarging on this point, he shows how by means of vegetative propagation populations of coffees may be established which possess uniformity of habit, uniformity in size of berry and bean, simultaneous cropping and resistance to pests and diseases.

The disadvantages are merely of a technical nature. Whilst it is obvious that more skill and attention will be required with this method of reproduction, the difficulties can be overcome and the advantages gained will more than compensate the additional attention necessary.

Methods of Vegetative Propagation.

The most common methods employed in reproducing plants asexually include propagation by cuttings (root, stem and leaf), layering, inarching, and budding and grafting. The object of the experimental work in progress is to ascertain which of these different methods are applicable to coffee.

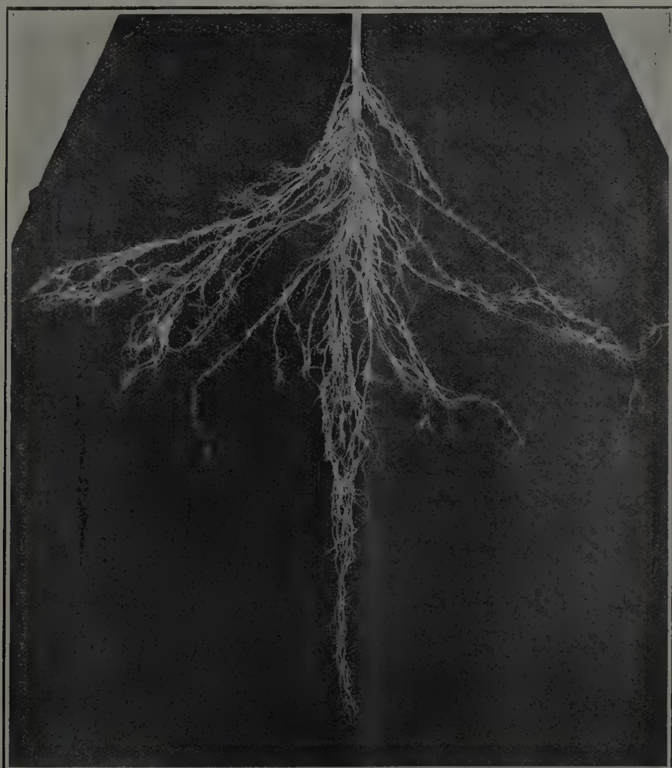


Fig. 2.
Root System of Seedling (approximately same age as Fig. 4).

It should be noted that, owing to the marked polarity of coffee, all material used for cuttings or for grafting is taken

from vertical growth. Lateral wood only produces low-growing, flattened trees.

The results obtained will be dealt with under their separate headings:—

Cuttings.

It is remarkable that so little work has been conducted on these lines in other countries. It may be due to the belief that cuttings do not produce good root systems or that they do not have the traditional tap-root of the seedling. That the seedling seldom produces a true tap-root and relies on a number of deep-rooting verticals is now proved, so no importance can be attached to this latter theory. The former suggestion is a possibility which cannot be overlooked, and merits further investigation. Experiments conducted to date nevertheless indicate that the root system of a cutting compares very favourably with that of a seedling tree and that trees 2-3 years old raised from cuttings are comparable with seedlings of the same age. The behaviour of these trees when bearing a crop and a comparison of their yield with seedling trees must be ascertained before it will be possible to make definite recommendations.

(*a*) *Hardwood.*—At the Scott Agricultural Laboratories, where most of the early work has been carried out, many hundreds of different types of hardwood cuttings have been planted out in open nurseries without success. In the Nandi District a coffee planter has been highly successful with this type of cutting, the material used being prunings from trees grown on the multiple stem system. Each cutting was approximately 2 ft. long and about 1-1½ ins. in diameter. How these cuttings will behave when they become mature trees must await further investigation, but it is interesting to note that they are already producing a prolific root system.

(*b*) *Softwood.*—The propagation of this type of cutting entails the use of a closed frame or propagator. Several different propagators have been tested. That which is most suitable to local conditions consists of frames artificially heated by ordinary hurricane lamps in chambers beneath with an overhead canopy. Sand, thoroughly washed and steam sterilized, is used as the rooting medium.

The type of cutting is of the utmost importance. That which has given the greatest success, although termed softwood, really consists of a tip, having semi-hardwood at the base, and allowed to retain its young tip leaves. The cutting used is 6-9 ins. long, and not more than a ¼ in. in diameter. Very suitable material will often be found growing as a bunch of suckers on a stumped tree, generally in the centre under dense shade. Attempts are now being made to induce this type of growth on a larger scale by various methods—shading, etc. Since the tip leaves must be retained, a high humidity must be maintained in the propagator, and thus the frames are opened up for a few minutes only each morning. The rooting medium, which is kept at a temperature between 68° and 72° F., requires watering about twice a week; on the other mornings the leaves of the cuttings are subjected to a fine spray of water in order to keep them fresh. Rooting may be expected in 3-4 months. Attempts have been made to stimulate the initiation of root growth by treating the cuttings with certain gases (4) and (5) prior to placing them in the propagators, but so far no success has been recorded.

(*c*) *Root and Leaf Cuttings.*—All attempts to propagate these types of cuttings have failed.

(*d*) *A Modified Form of Layering.*—Both correct layering and marcotting gave success during the first experiments conducted, but due to the tedious nature of the work and the slow rate at which it would be possible to raise large clonal populations, other methods were sought. Early work proved that if suckers, growing from an old stumped tree, were ring-barked near the parent stump, and then etiolated, they would root with comparative ease provided suitable weather conditions prevailed. This indicated that if some method could be found whereby the parent material could be made to produce a larger area for the production of sucker growth, little difficulty would be experienced in raising large clonal populations. Thus a technique has been evolved, and whilst, due to drought conditions, it is impossible to give more than early observations, it is satisfactory to

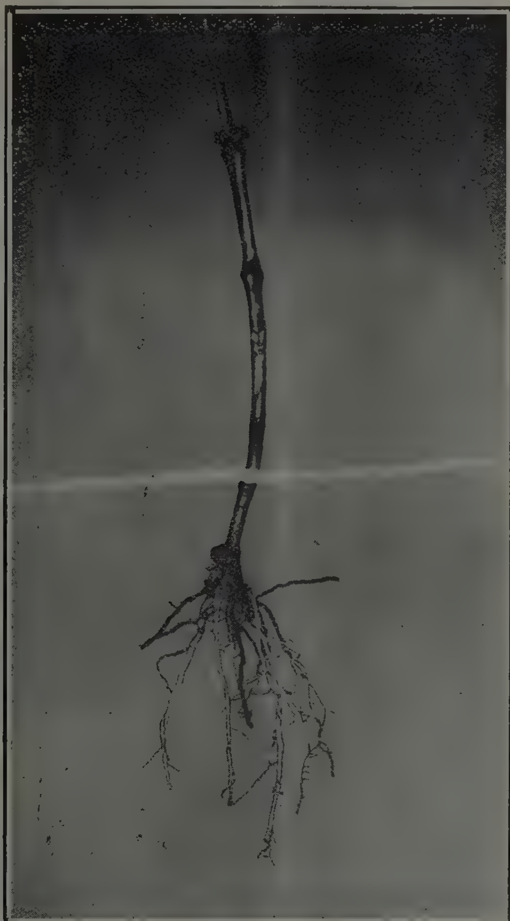


FIG. 3.
Root System of Rooted Cutting (early stage).

note that these are most hopeful. The following is the method adopted: A rooted cutting from a selected tree is planted out in a nursery at an angle of approximately 25° from the horizontal. By keeping it pegged down, it will continue to grow in this plane. As this plant grows, suckers come away from the axillary buds. When about 12 ins. high they are ring-barked at the base, and soil banked round them. When rooted, the soil is removed and the sucker cut away from the parent plant, which again will produce further cycles of suckers for similar treatment. In the first cycle only a few of the rooted suckers should be removed, the remainder being pegged over at right angles to the original plant to provide a larger area for the production of rooting material in the second and subsequent cycles. Experimentation has shown that earthing up must not be carried out until the suckers are ready for rooting, and even then it is necessary to ring-bark each sucker.

Budding.

When the study of the vegetative propagation of coffee was commenced, considerable attention was given to the possibilities of budding, but it has been found that the technique presents several difficulties, so the method has been abandoned in favour of grafting. It is of interest to note that in referring to budding, Marshall (4) says, " The union of stock and scion is much weaker than when grafting is used. In heavy wind the entire growth is liable to break back to where the original bud was inserted."

Grafting.

Inarching. — Methods of inarching young seedlings in the nursery and of inarching one-year old plants on to old stumped trees in the field were first attempted with considerable success by Rogers, Superintendent of Plantations at Amani (6). Adopting his methods, success has also been obtained here, and it would appear that either system is an easy way of grafting one variety of coffee on to another (*Arabica* on to *Robusta*). Unfortunately, with this method, both stock and scion must be seedling material, an arrangement by which little ultimate gain can be obtained.

Cleft Grafting in the Nursery.—Most attention has been paid to this form of grafting, as by this method it is possible to graft clonal scion material on to seedling stocks. Many hundreds of grafts have been made during the past two years in order to establish a technique which would give a high percentage of successful unions. As a result of this experimentation it would appear that the following points should be observed:—

(*a*) *Size of Stock and Scion.*—The larger the stock and scion the easier it is to obtain success. Seedling stocks about 18-24 months old are much easier to graft on to than younger material. If possible, the scion wood should be the same size as the stock, but this is not essential. With smaller scion material great care must of course be exercised to ensure that one cambium region is in contact with one cambium region of the stock.

(*b*) *Method of Making the Graft.*—The stock should be cut just above or across a node, and a cleft about 2 ins. deep made between the buds. The scion, which must bear at least one bud (and, if material is plentiful, two or three are preferable), is cut in the form of a wedge, beginning on either side of a bud. If the scion material is the same size as the stock, both edges of the wedge should be cut the same. If, on the other hand, the former material is smaller, one edge of the wedge should be slightly narrower than the other, and when inserted into the cleft the narrower side is placed toward the centre of the stock. This ensures perfect contact of the cambium

regions. The scion wood should be active at the time of grafting.

(c) *Binding and Waxing.*—Having inserted the wedge of the scion into the cleft, it must be protected to prevent movement until a union has been obtained. Observations show that the nature of the protection should vary according to the time of the year at which the graft is made. It has been found that the best time of the year for grafting at the Scott Agricultural Laboratories is during the cool, dry weather (June-October). Grafting in June, when sap flows freely from the stock, it will only be necessary to bind the graft with gunny string. Grafting later in the season (September), at a time when there is little sap flow and the weather is warmer, it is advisable to protect all the cut surfaces, including the tip of the scion, with grafting wax. In all cases the whole

Fig. 4.
Root System of Cutting.

should be protected for a period of about three weeks by covering it with a loose waxed paper cover.

Provided these methods are followed a high percentage of success may be expected.

Cleft Grafting in the Field on to Old Stocks.—The obvious method to adopt in grafting on to old stocks in the field would be that of "rind" grafting, a method by which the scion wood is inserted between the bark and the cambium layer of the actual stock itself. Unfortunately, the method has proved entirely unsuccessful to date, so that other ways have had to be exploited. The method adopted, and which is proving successful, is that of grafting on to sucker growth encouraged from the base of the tree. When the sucker has obtained sufficient size and maturity it is treated in precisely the same manner as the seedling stocks are in the nursery. The ordinary cleft graft is made as described above, and is waxed and covered with a paper cover as before. The tree may be stumped back to the sucker, either before grafting or afterwards. If it is left until after grafting the natural shade thus formed will assist the newly made graft in its early days. Care must nevertheless be taken to stump before the graft makes too much growth, or it will be drawn up and tend to become whippy. The growth of a graft on an old established root-stock will be remarkably rapid.

Recommendations.

It is known that many planters are becoming increasingly interested in this method of reproduction, and it is felt that it is here advisable to warn them against embarking on any large scheme of vegetative propagation work until such time as the Department is in a position to make definite recommendations, which can only be made after several years of careful observations and recordings.

Possibly one of the first great advantages to be obtained will be the improvement of established plantations by top-grafting. It is to this aspect of the work that the planter should commence giving serious thought. The variation in yield and quality of bean existing between individual trees in a plantation is great. Whilst all trees may appear to the casual eye to be uniform, on closer examination it will be found that the percentage of "passengers" or unprofitable trees in most plantations is high. This variation could be considerably decreased if all the low-yielding trees were top-grafted with scion material from a known heavy-yielding parent tree. It is worthy of note that in East Java, where the method has been used on a large scale on some estates, the resulting yield has been increased in some cases by as much as 60 per cent (3). Mention has already been made of the method employed for top-grafting in the field on to old stocks. Before commencing actual grafting the planter should make a careful study of his plantation in order to pick out trees which produce a high yield of good quality coffee annually. These will subsequently be required as parent trees for the supply of scion material. It is not sufficient to work on one tree only, as it is quite possible that a high-yielding tree growing on its own stock may behave differently when grafted. Therefore a number of trees should be available for early investigation of their behaviour when used for this purpose. Individual trees throughout the plantation should also be subjected to close examination for a period of at least two years. If during this time little or no crop is harvested from them, they are obviously uneconomic units and should be prepared for grafting scion wood of the selected parent trees on to them at a later date.

Studies.

Experimental work being conducted by the Coffee Section of the Department on this subject covers a wide sphere of work. This includes—

(*a*) Studies on the technique of rooting cuttings and their subsequent behaviour.

(*b*) Methods of grafting.

(*c*) Relation between stock and scion.

(*d*) The possibilities of grafting as a means of combating disease.

(*e*) A comparison of the behaviour of *Arabica* coffee when growing on different root-stocks. These include *Arabica* types, other varieties and hybrids.

(*f*) Selection of high-yielding trees for future use as parents for scion material.

(*g*) A comparison of growth and yield between seedling, grafted, and cutting material.

(*h*) A study of the variation occurring between individuals in populations of trees propagated from seed, from grafts and vegetatively on their own roots.

(*i*) The raising of monoclonal populations of selected trees by grafting.

(*j*) The possibilities of hybrids are of the utmost importance. Breeding work has been commenced, and it is hoped that soon useful material will be obtained from crosses which are being made.

Acknowledgments.

The writer is indebted to officers of the Departments of Agriculture in Kenya, Uganda and Tanganyika Territory, and the East African Agricultural Research Station, Amani, for their advice and assistance at all times; to Mr. E. C. M. Green, Field Assistant, for his care of the field and breeding work; and to Mr. L. Burton, Laboratory Assistant, for the photographs produced in this paper.

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Reviews

TERMITES AND TERMITE CONTROL: Charles A. Kofoid, Editor-in-Chief. Second Edition, Revised. Berkeley, University of California Press, 1934.

No one who lives in the tropics can be unaware of the activities of termites, and to anyone who is concerned with the construction and maintenance of any form of woodwork, no less than to the entomologist who is continually being consulted about this order of insects, the publication of this book is of no little importance.

It takes the form of a report to the Termite Investigation Committee, which was formed in 1927 to direct fundamental research on the bionomics and control of termites on the Pacific coast of America, and is an authoritative and comprehensive treatise, written as far as possible in non-technical language, by thirty-five authors in collaboration.

Part I, consisting of 32 chapters, deals with termites and their biology. Some 1,500 species have been described, of which, however, about 1,200 belong to the family *Termitidæ,* which contains few species of economic importance. This is due to the fact that they do not as a rule attack sound wood, being for the most part deficient in the intestinal protozoa which enable species of the other families to make use of cellulose as food. The majority of species that are major pests belong to the family *Rhinotermitidæ*, though some, including a few that attack living plants, are members of the *Kalotermitidæ*. The other two families are of little importance—the *Mastotermitidæ* consists of a single primitive species found in Australia, while the *Hodotermitidæ* are mainly grass-feeding (though species of Hodotermes occasionally damage wallpaper and similar materials in Africa). This latter family also does not occur in America, which has, however, for a country lying wholly outside the tropics, an exceptionally large termite fauna, some 55 species—compared with only two in Europe—being already known. Of these, 8 are of major and 10 of minor economic importance.

In Chapter XII the species of termites are divided into a small number of groups from the practical point of view of their habitats and habits.

All termites are either wood-dwelling or ground-dwelling. In the former group the colonizing pair always enter wood directly, and the colony is confined entirely to wood. These are further subdivided into: (1) Damp-wood termites, which require wood of a high moisture content, usually decaying, though they are capable of extending their activities into dry and sound wood, and sometimes do serious damage, often in conjunction with fungus attack, to structure in contact with a constant moisture supply; (2) Dry-wood termites proper, which feed on dry sound wood, and are responsible for most of the damage by wood-dwelling termites, especially outside the tropics; (3) A group which requires more moisture than the last. This they obtain from living plants, usually starting their attack in dead wood, but subsequently doing serious damage to living tissue. There are species of this group which attack tea and coffee in Ceylon and teak in Java. They do not as a rule attack cut timber.

The ground-dwelling termites make their colonies in the soil, and usually construct covered runways from the nest to the wood on which they feed. They comprise four groups: (1) The subterranean termites, which include the species responsible for more damage than any other group. These make their nests below

ground level, and do not build mounds. They belong to the three genera, *Reticulitermes, Heterotermes,* and *Coptotermes*. Some species of the last-named genus form colonies isolated from the ground, and have even been found infesting the woodwork of ships. (2) The Desert termites also have their colonies below ground level, but are separated from the preceding group on account of their different habits. They usually attack only the outer surface of weathered wood, and seldom cause any damage to wooden structures. (3) The Mound-building termites, which are such a conspicuous feature of an African landscape, are not found in North America, though the species occurring in the Philippines are dealt with. This group, like (4), the carton-nest-building termites, is seldom of much economic importance, except that their hard and durable mounds present problems to the cultivator, as any farmer in East Africa knows, and that money has often been wasted in attempting to destroy them when the damage it was intended to prevent was, in fact, being caused by species of other groups.

It is obvious that a knowledge of the habits of the species concerned is an essential preliminary to termite control. The two fundamental principles of control are either to prevent materials being reached by the termites, or to use only materials which are, or have been artificially rendered, distasteful. Either method may be of value against earth-dwelling termites, but the former is clearly useless against dry-wood termites, which can fly to any part of a wooden structure and there found a new colony.

Part II consists of eight chapters on chemical investigations. Treated wood is only completely termite-proof if it is rendered toxic, though if the preservative used is sufficiently distasteful to termites to check infestation, it may be adequately termite resistant for practical purposes. Although experiments on the value of various arsenic compounds are fully discussed, the authors are emphatic that arsenic in any form should not be used where there exists any possibility of direct or indirect contact with human beings.

Part III contains five chapters dealing with the resistance of wood and other cellulose-containing building materials, both treated and untreated. No American wood is mentioned which, untreated, is completely termite proof. (It may be added that, in the reviewer's experience, the heartwood of Mvuli (*Chlorophora excelsa* Benth. and Hook.) is never attacked by termites in Africa, even though untreated and unpainted.)

Part IV deals with the prevention and repair of termite damage, and comprises twelve chapters of the greatest value to engineers and builders. So varied are the recommendations made that it is not possible to summarize them in a short review. They deal not only with wooden buildings but also with power and telegraph lines, railroads and bridges, and timber storage piles. One chapter deals with legislation connected with termites in the U.S.A., and the last chapter is concerned with the association of termites with fungi capable of giving off toxic arsenical gases.

A few minor criticisms may be made. Some of the unavoidable technical terms are inadequately explained. For instance, the "fontanel" (a pale-coloured depression on the head containing the frontal pore or external orifice of the frontal gland) is an important diagnostic character referred to in Chapter X on the classification of termites, but, even though it is a term with which many entomologists might be unfamiliar, it does not appear to be explained, either in the text or in a figure. Nor is there any mention of this characteristic termite organ in the chapter on external anatomy, which is based

mainly on a species of *Kalotermitidæ*, a family in which the fontanel is absent.

The chapter on "A World View of Termites" could with advantage be considerably extended. Keys to the genera, and a list of the more important destructive species in all countries, would enhance the value of the book for workers outside America. Some of the reproductions of photographs are scarcely up to the standard of the rest of the volume. The index, which was apparently added as an afterthought to the second edition, is hardly adequate, at least as regards entomological subjects.

This is a book which will naturally be found on the shelves of every entomological library, but it is also virtually indispensable to every architect and constructional engineer in the tropics. It only remains to add that a list of the contents of the 57 chapters, with the names of their respective authors is to be found in the *Review of Applied Entomology*, Series A, 22, pp. 254-256, and that the exceptionally low price for a volume of this nature (22s. 6d.) is due to the generosity, or rather foresight, of the firms which financed the research undertaken and the publication of the report.

T.W.K.

A MANUAL OF ENTOMOLOGICAL EQUIPMENT AND METHODS, *Part I, by* Alvah Peterson. Edwards Brothers, Ann Arbor, Michigan, 1934; $3/75.

An American publisher recently said that "Any book can be sold by its title." Largely because of the amount of truth in this statement, it appears worth while to give a short review of this publication.

The first part consists of instructions for erecting a field insectary, which might be of some value to an entomologist who, like the proverbial Irishman, does not know what he wants and won't be happy till he gets it, but who, unlike most Irishmen and all entomologists in East Africa, has a large fund of money at his disposal. However, it contains such useful hints as that "electricity and running water are extremely valuable features for careful scientific work" and "electricity provides light for observations particularly on cloudy days".

The greater part of the volume consists of 138 plates, each containing a number of figures, with short explanatory footnotes. Whereas these notes are quite sufficient to explain such figures as those of a wide-mouthed bottle, a dessicator, or a U-tube (Plate 12)—should there be any entomologist who is unaware of the nature of such articles—it could hardly be expected that even a skilled engineer could construct some of the more complicated pieces of apparatus, such as temperature and humidity conditioning cabinets, from the inadequate information provided. However, full references to the original descriptions are given, and these are the most, if not the only, useful feature of the book.

But it would be ungenerous to criticize further. The almost perfect drawing of "a piece of paper" (Plate 59, Fig. 3); the delightful illustration of ten apples impaled on ten nails (Plate 130, Fig. 8), and the masterpiece of a pair of boots (which for some obscure reason are labelled "Man") projecting from a bag (Plate 20, Fig. 9), are more than worth the price asked.

Nobody who reads the foregoing review will believe that it is not exaggerated. He will therefore buy the book in order to prove to himself that the reviewer has been unfair. In this he will be disappointed, but one of the main functions of a good review—to increase sales—will have been fulfilled.

T.W.K.

The Climate and Weather of East and Central Africa

By A. WALTER, O.B.E.,
Director of the B.E.A. Meteorological Service.

In a journal devoted to the interests of agriculture in tropical Africa, it would be a platitude to emphasize the importance of a proper understanding of climatic conditions in all problems connected with agricultural pursuits.

In the series of articles which it is proposed to publish in this Journal quarterly, the first four will be devoted to the conditions as revealed by a study of the synoptic weather charts which are now prepared daily by the British East African Meteorological Service.

In order to understand the significance of the values which will be given in these articles it is necessary to explain briefly the general organization of this service.

The headquarters are situated in Nairobi, a town from which communications to all other parts of Africa, whether by road, rail or 'plane, as well as telegraph, telephone and wireless, are comparatively easy. The area covered, and from which detailed observations are being secured, comprises the territories of Uganda, Kenya, Tanganyika, Zanzibar, and Northern Rhodesia. Central territorial stations have been erected at Kampala, Nairobi, Zanzibar, Tabora, and Broken Hill, and from these stations continuous records of the various meteorological elements are secured. In addition to these central territorial offices and observatories, stations known as "second order stations", at which two observations a day are secured, have been established at—

Kenya.—Eldoret (Health Office), Kabete (Reformatory), Kabete (Scott Agricultural Laboratories), Kiambu (Kasarini), Kisumu (Marine Department), Kitale (District Commissioner), Limuru (Togi Farm), Mombasa Observatory, Moyale (District Commissioner), Nakuru (District Commissioner).

Tanganyika.—Dar es Salaam (Malaria Research), Dodoma, Iringa (Medical Officer), Kigoma (Wireless Officer), Kondoa Irangi, Mbeya, Moshi (Wireless Operator), Mwanza, Lindi, Musoma, Bukoba.

Uganda.—Butiaba, Entebbe, Fort Portal, Gulu, Jinja, Kabale, Kirwa Island, Masaka, Masindi, Mbale, Mbarara, Mubende, Ngetta Lira, Soroti, Tororo.

Broken Hill.—Abercorn Boma, Broken Hill Mine, Bwana Mkubwa, Fort Jameson, Kasama, Livingstone Observatory, Mazabuka Research Station, Mpika Aerodrome.

Rainfall observations are secured from about 800 stations scattered over the whole of East and Central Africa, while, at many of these stations, additional observations are obtained of maximum and minimum temperature, cloud and wind direction and force, generally for two periods of the day—one in the early morning and one in the afternoon.

Observations are telegraphed to the central office from all second order stations daily, and, in addition, the wireless broadcast messages from Cairo, Belgian Congo, Madagascar, Portuguese East Africa and Southern Rhodesia are received in the central office on a specially constructed wireless receiving set. It will be seen therefore that it is possible to construct every day by 11.30 a.m. a complete picture of meteorological conditions over the whole of this hitherto uncharted territory of East and Central Africa.

The Position in Relation to the General Circulation of World Meteorology.

It will be found as we proceed that the meteorology of the region we are considering is greatly complicated by the

varying altitudes of the land, by the great lake system, and by the Rift Valley.

These complications will be better understood if, first of all, we consider the general circulation on which the other variations are imposed.

North and south of the tropical belt lie two anti-cyclonic or desert-producing areas. These regions are *divective* regions; that is to say that, generally, the surface air is flowing out of these anti-cyclonic zones. Between them lie the tropics—the zone with which we are principally concerned. This is the great *advective* region of the world, and surface air flows into it from the north and south.

The relative position of the tropical belt to the two anti-cyclonic regions is determined by the migration of the sun, north and south, between winter and summer. During the southern winter, when the sun is at its extreme limit north, the southern anti-cyclonic area penetrates well into East and Central Africa, and the tropical advective zone has shifted north into Egypt.

During the southern summer, the reverse takes place, and the great northern anti-cyclonic area enters the northern part of our territory.

This migration of the climatic zone brings with it conflict of air currents, and where this conflict takes place there is discontinuity in the general trend of the main weather system and consequent disturbance and rainfall. This rainfall we refer to as frontal rainfall. So long as the tropical advective region remains established over any given zone, a strong thermal convection takes place, either directly under the sun or covers an area several degrees on either side of it. It will be seen, however, later on, that circumstances may extend this intense convection area over the greater part of the tropical region, and we find, as in the present year, that convection rains become general from the lake area to the Rhodesias.

A clearer conception of the conditions which obtain over the tropical zone and on either side of the tropics can be obtained by considering the ocean areas, where the full play of wind currents flowing from the anti-cyclonic zones into the tropical zone can be observed, free from the disturbing effect of the high plateau and varying altitudes which occur over the land areas. Over the ocean we find that, in the southern summer, the low-pressure tropical zone, known as the Doldrums, extends as far south as 12° latitude. Into this region of low pressure flow two main currents, one from the south, the south-east trade, and the other from the north, the north-east trade. As the latter crosses the Equator southwards, it is deflected into a north-westerly current, and we find the tropical low-pressure zone, when south of the Equator, exposed to the effect of two strong currents—one from the north-west and the other from the south-east. In this zone of discontinuity the cyclonic disturbances of the South Indian Ocean form. As the sun moves north, the whole of this system moves north with it, and as the tropical zone crosses the Equator, where the deflecting force of the earth's rotation is non-existent, cyclonic storms do not occur; but as it establishes itself in the northern hemisphere the cyclone season commences north of the Equator, and the south-east trade, sweeping over the Equator, becomes a south-west current in the northern hemisphere, in the same way as the north-east current was deflected into a north-westerly as soon as it crossed the Equator going southward; the north-east current is now only felt in Asia. The south-westerly current, which is thus a continuation of the south-east trade, then produces the south-westerly monsoon of India. This describes the surface conditions. As we go up through the

depth of the surface current we find a horizontal layer of calms, above which a north-easterly exists. This current appears to become a north-westerly as it penetrates into the southern hemisphere. This is the picture which is generally shown in the text-books on physical geography and meteorology.

Hitherto such a condition has been extrapolated into the tropical areas of Africa, but the establishment of the British East African Meteorological Service has made it possible to chart the actual conditions over the land area, and it is found that these simple relations between the two anti-cyclonic areas and the tropical zone do not obtain over the African Highlands, although the general movement of the air currents as described above must be held responsible for the seasonal changes which occur.

The Change of Seasons over East and Central Africa.

It will be realized that this migration of the sun and the various climatic zones gives rise to a single season's rainfall at the two extremes of the migration and two seasons at the intermediate points.

A study of the synoptic charts indicates the existence of a permanent low-pressure area over the great lake. The effect of this inland sea is felt on the daily temperature range and on the humidity and rainfall conditions for a distance of about one hundred miles, and affects profoundly the distribution of plant life over this area.

The rains over the lake area are continuous throughout the year, intensifying as the migrating rain belt passes over the area in its journey north and south.

During the months of December and January there appears to be a zone of high pressure immediately south of the lake, extending over Tanganyika and into the Kenya Highlands. This produces the dry sunny period in the regions between what are popularly known as the "short rains" of October to December and the "long rains", which begin normally towards the end of March.

During the period of February and the early part of March the sun is on its way northward, and the "grass rains", which fall in the form of thermal convection showers, break the severity of the drought period. These grass rains increase gradually in intensity until the sun is overhead. If the conditions of the southern trade are favourable, the air along the southern border of the tropical low-pressure zone is thrown into violent turbulence and the heavy rains set in. Any cause which either delays or deflects the southern trades appears to leave the central parts of the East African territories with only the thermal convection showers. While these are at times intense, they are patchy and irregular in distribution, and do not produce that continuous soaking of the soil which is such an important factor in the agricultural life of the East and Central African territories.

Once the south-east trade is established, the coastal zones become well watered, and rain falls heavily on the slopes of the mountains exposed to the trade wind current. In the Highlands generally, however, light misty morning rains are all that are experienced during the months of June and July.

From June to September, the greater part of Tanganyika is without rain, except along the coast. The "short rains" then establish themselves, but the zonal variations are very considerable, and will be dealt with in subsequent articles as the returns are compiled and analysed.